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The central role of stress relief in video gaming motivations and preferences

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Video games are played by more than 1.8 billion people and are a pervasive force in society, but despite decades of research there has been little consensus on their effects. Before we are able to model complex outcomes such as excessive engagement, we must first understand how and why people play video games. This dissertation integrates latent factor models with techniques from machine learning and network analysis to develop a holistic picture of gaming style, motivations, and individual differences. It employs diverse sources of data across several studies and a total of 2,143 participants, combining online questionnaires with qualitative analysis of participant responses and objective information about gaming behaviour from the API of the popular gaming network "Steam". By combining a latent factor model of gaming style with network analysis of reasons for playing games, I find that stress relief is a primary motivation for engaging in the immersive worlds of video games.

Previous research has indicated three underlying factors of Immersion, Achievement and Socialising which replicated across three comprehensive studies of 480 adults, 106 adults and children with an Autism Spectrum Condition, and 961 adults and adolescents. Gamers experiencing more stress in their daily lives were more likely to have Immersion rather than Social or Achievement play styles. Achievement-oriented gamers tended to be lower in stress, higher in conscientiousness and emotional stability, and played more than Immersion-focused gamers.

A qualitative analysis of 54 gamers' descriptions of why they recently chose to play a game was used to develop the "Reasons for Playing Video Games" items (RPVG), which were administered to independent samples of 243, 299 and 961 gamers. The *qgraph* R package was used to perform network analyses of the RPVG items and gameplay style factors, employing the machine learning-based adaptive LASSO technique to estimate a partial correlation matrix from a set of variables as a Pairwise Markov Random Field. Gamers higher in Immersion tended to play for escapism, distraction, and fantasy, while social gamers played for excitement, energy, and self-expression. Network analysis and graph theory illustrate the central role of stress relief in the network of Reasons for Playing Video Games and shows that playing when feeling stressed is strongly linked with Immersion.

Declaration

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except as declared in the Preface and specified in the text.

It is not substantially the same as any that I have submitted, or, is being concurrently submitted for a degree or diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text. I further state that no substantial part of my dissertation has already been submitted, or, is being concurrently submitted for any such degree, diploma or other qualification at the University of Cambridge or any other University or similar institution except as declared in the Preface and specified in the text.

It does not exceed the prescribed word limit of 60,000 words.

This work is dedicated to my parents, who taught me how to learn.

Acknowledgements

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Finally, I want to express my gratitude to Brad Feld and Amy Bachelor. Their generous support of my education gave me the freedom to follow my intuition and my heart. Thank you for believing in me.

CONTENTS

CHAPTER 1

INTRODUCTION: EXPLORING VIRTUAL SPACES

As I write this, I am sitting in a mostly-empty train carriage on my way from Cambridge to London. A few seats away, a young couple are discussing their favourite works of fiction. "I feel like growing up in the video game generation has spoiled me," says the young man. "It's not that I don't like reading fiction, it's just that games are so much more immersive. The story is more engaging when you're actually the protagonist." Across the aisle, a boy about eight years old and dressed in a colourful Super Mario t-shirt is engrossed with his Nintendo Switch, humming along to the music as his mum watches interestedly over his shoulder, happy to share in the entertainment.

Video games are a pervasive and growing phenomenon in modern society. In 2017, video game industry sales were worth nearly $110 billion (NewZoo, 2017), and the virtual worlds of games are inhabited by about 1.8 billion people (McKane, 2016). Most of the early research on video games addressed the question of whether violent games cause violent behaviour, a debate which is still ongoing (Anderson, 2004; Ferguson, 2010; Gentile, Lynch, Linder, & Walsh, 2004), but in more recent years both the media and the scientific community have begun to acknowledge the positive effects of gaming as well as the wide variety of genres of video games and the diverse worlds and experiences they create.

Much of the existing scientific research has focused on "serious" games rather than recreational games. Serious games include those designed for education or classroom use (Rizzo et al., 2000; Short, 2012), job training (Seymour et al., 2002), work collaboration (Erickson, Shami, Kellogg, & Levine, 2011), or as part of treatment for conditions such as post-traumatic stress disorder and anxiety (Gamberini, Barresi, Maier, & Scarpetta, 2008; Holmes, 2009). There has been some attention on the beneficial side-effects of recreational gaming, including enhanced spatial awareness (Ash, 2009; Spence & Feng, 2010), selective attention (Green & Bavelier, 2003), problem solving (Baranowski, Buday, Thompson, & Baranowski, 2008), and visual acuity and processing (Dye, Green, & Bavelier, 2009). Despite this growing literature on the positive effects and uses of games and virtual environments, we know little about the precise motivations for or individual differences in recreational gameplay preference and style.

Early history of video games

In the early 1950s, engineers began using interactive games with visual displays to show off the latest advances in computing technology. Visitors to the 1950 Canadian National Exposition could play tic-tac-toe against Bertie the Brain, a four-meter high computer built to demonstrate a new miniature vacuum tube (Bateman, 2014). A year later, the Festival of Britain featured The Nimrod, which challenged players to a game of Nim and showcased the computer's ability to do mathematical computations (Wolf, 2012). Bertie the Brain and The Nimrod were single purpose, one-of-a-kind behemoths that were dismantled after a few weeks on display.

The 1962 space combat simulator *Spacewar!* was one of the first video games to be available on multiple machines. Developed at MIT for the new PDP-1 computer system, *Spacewar!* was a competitive two-player game featuring spaceships with torpedos, limited fuel, an accurate star chart and Newtonian physics and was one of the first video games to be intended as entertainment as much as technical display (Graetz, 1981). *Spacewar!* became extremely popular within the programming community and inspired several similar games, among them the 1971 *Computer Space*, the first commercially-available video game in history (Rutter & Bryce, 2006).

These space simulators took their inspiration from the science fiction stories and films of the time (Graetz, 1981), the last years of the so-called "Golden Age" of science fiction (Roberts, 2002), and with the Space Race between the United States and the Soviet Union in full swing, it is unsurprising that the first video games involved space travel. Video games could give players an experience they could not have in real life, in a much more immersive way than any film or book.

Computer Space developers Nolan Bushnell and Ted Dabney went on to incorporate as Atari and along with designer Allan Alcorn they released the first truly successful video game, *Pong* (Generation, 1995). *Pong* was installed in arcades across the United States, selling more than 8,000 units by the end of 1974 (Kent, 2001). Atari co-founder Bushnell highlighted the social aspect of *Pong*: "It was very common to have a girl with a quarter in hand pull a guy off a bar stool and say, 'I'd like to play Pong and there's nobody to play.' It was a way you could play games, you were sitting shoulder to shoulder, you could talk, you could laugh, you could challenge each other [...] As you became better friends, you could put down your beer and hug. You could put your arm around the person. You could play left-handed if you so desired. In fact, there are a lot of people who have come up to me over the years and said, 'I met my wife playing Pong,' and that's kind of a nice thing to have achieved." (Generation, 1995)

What is a "video game"?

Today, electronic games are everywhere, ranging in style and complexity from casual smartphone games to technical flight simulators to vast and detailed open-world adventures. In this dissertation, I have focused on recreational rather than "serious" games, but otherwise have not restricted the definition of a video game beyond "an interactive electronic audio-visual stimuli". The level of interactivity varies greatly among game genres; some, such as virtual "novels" only require an occasional input from the player to progress the story, but without some level of dynamic response to user input, a video game would be indistinguishable from a film. I specify "electronic" to distinguish video games from tabletop board games and card games, though I

Numbers of papers focusing on each aspect of engagement by study design.

Aspect of engagement	Study design: RCT	Quasi-experimental	Survey	Qualitative	Total
Subjective experience	2	9	1	1	13
Physiological responses		7			7
Motives for playing		2	14	2	18
Game usage			7		7
Games market and loyalty to game			3		3
Impact of game on life satisfaction		1	6		7
Total	2	19	31	3	55

Figure 1.1: Review of empirical studies of positive aspects of gaming, Boyle et al.

expect there are overlaps in motivations and preferences between electronic and non-electronic gaming.

Recent research

The earliest research into gaming motivations began in the 1980s as video game arcades became prevalent. Gary Selnow investigated what he called "the electronic friend" in a questionnaire study of 244 adolescents, finding that games fulfilled similar needs to television, but their interactive component made them especially appealing (Selnow, 1984). Selnow noted with some concern that games were often preferable to human companionship, and he identified three dimensions of gaming motivations: social needs, activity/action, and solitude/escape. Another study of arcades found that games fulfilled the needs of excitement, tension-reduction, and the satisfaction of doing well, but did not emphasise the social aspects (Wigand, Borstelmann, & Boster, 1985). A 1990 study used Q methodology to explore the subjective elements of gaming aesthetics, identifying the four important criteria of fantasy, curiosity (novelty), challenge, and interactivity (Myers, 1990).

As gaming expanded out of the arcade and became more prevalent in the home, research into the subject increased at a rapid pace. By 2012, there were nearly 20,000 published academic papers dealing with video games (Boyle, Connolly, Hainey, & Boyle, 2012), most of which were not empirical and dealt with the negative effects of games, especially the ongoing debate over whether video games cause violent behaviour (Anderson, 2004; Ferguson, 2010; Gentile et al., 2004).

After narrowing down the list to empirical studies of non-serious (education or training) games published in academic journals and focusing on positive aspects of games, Boyle et al. identified only 55 papers published between 2001 and 2011 (Boyle et al., 2012).

The most prevalent categories of gaming engagement research focused on the subjective moment-to-moment experience of gaming, physiological responses such as heart rate variability, motives for playing ("more enduring appraisals of players' reasons for playing games" (p. 773), which was the most researched category, with 14 papers), and game usage (the least researched category, comprising only 7 papers, all of which were surveys).

Two paths

Gaming motivations research has generally followed two paths, one originating within the gaming industry and informed by observations of early online multiplayer games, and the other from media and communications research. The conceptualisation and theoretical framework of the two paths is subtly different, and I believe this difference is not just a reflection of their different origins but a reflection of two distinct aspects of individual differences in gaming. These distinct aspects are gameplay *style* and gameplay *motivations*.

The first path begins with Richard Bartle, a pioneer of online game design and professor of computer science who theorised four player types in multiplayer video games: Killers, Socializers, Achievers, and Explorers. These types have been used extensively by game designers and are the basis for the "Bartle Test", which was developed by Erwin S. Andreasen and Brandon A. Downey in 1999 and has been taken by over 800,000 gamers.[1] Bartle's player types received more empirical treatment by Nick Yee in 2007. Yee's principal components analysis of 40 items based on Bartle's types indicated three components and ten subcomponents: *Achievement* (advancement, mechanics, competition); *Social* (socializing, relationship, teamwork); and *Immersion* (discovery, role-playing, customization, escapism) (Yee, 2007). Yee's components were replicated by Graham and Gosling in their 2013 study of World of Warcraft players. They reproduced Yee's factors of Socializing, Achievement, and Immersion, which they further split into Exploration and Dissociation, and found that these were related to Big Five personality traits (Graham & Gosling, 2013).

Immersion is both a motivation for and characteristic of gaming and has been studied extensively in its own right (Brockmyer et al., 2009; Jennett et al., 2008). Indeed, Csikzentmihalyi's Flow Theory (1999) provides yet another compelling framework for gaming engagement, in which gamers are motivated to play primarily for the enjoyable experience of flow (Sherry, 2004). Many games attempt to provide an 'optimal' level of challenge with manual and sometimes automatic difficulty scaling, one of the hallmarks of the flow experience. Another key element of flow is a sense of dissociation with the outside world, especially a sense of 'losing track of time' (*Time flies*, as the adage says, *when you're having fun.*)

The other path originates from media research, particularly Uses and Gratifications theory (Ruggiero, 2000), and has focused on the reasons people choose to play games rather than how they differ in style. Sherry's 2003 study identified the six factors of competition, challenge, social interaction, diversion (to pass time or alleviate boredom), fantasy (doing things you cannot do in real life), and arousal (playing because the game is exciting) (Sherry, Lucas, Greenberg, & Lachlan, 2006), while Demetrovics's "Motives for online gaming questionnaire" found evidence for seven factors: social, escape, competition, coping, skill development, fantasy, and recreation (Demetrovics et al., 2011). Park found five factors of motivations for playing massively multiplayer online role-playing games (MMORPGs, such as World of Warcraft): relationships, adventure, escapism, relaxation, and achievement Park, Song, & Teng (2011). Table 1 summarises the overlap of the factor structures found by these five studies. Shaded cells indicate that a factor

[1] http://www.gamerdna.com/bartle.php

	Sherry	Yee	Demetrovics	Graham	Park
social	■	■	■	■	■
achievement		■	■	■	■
fantasy	■		■		■
escapism		■	■		■
immersion		■		■	
competition	■	■	■		
recreation			■		
challenge	■				
coping			■		
relaxation					■
diversion	■				
arousal	■				

Table 1.1: Comparison of gaming motivation factors

was found by the study in that column. Names of factors matched exactly except in two cases: Demetrovics's "skill development" factor is considered "achievement" and Park's "adventure" factor is considered "fantasy."

All five studies found a "social" factor and four of the five found some kind of "achievement" factor, though one could argue that challenge and competition are expressions of achievement. Only Demetrovics found a factor related to coping or stress relief. Yee considered escapism a facet of immersion, while Demetrovics saw escapism as a factor in its own right and omits the immersion factor altogether.

To make any sense of these overlapping models of gaming preferences, we must first untangle gameplay *style* from gaming *motivations*. Yee's robust three-factor model of Achievement, Immersion, and Socialising has its origin with Bartle's player types, describing the way in which gamers interact with and within a game: gameplay style. These three factors manifest even beyond the individual level. The early history of video games begins with technological marvels like Nimrod that showcased the computer's ability to play a game of strategy and offered players the opportunity to try to beat it. The first game to have a wider community of players and contributors was the immersive *Spacewar!* with its realistic physics system and romantic science fiction inspiration. Video games became a commercial success with *Pong*: while its gameplay mechanics were extremely simple compared with games like Spacewar, its draw was the social experience of standing side by side for some friendly competition.

Gameplay style has direct links with gaming motivation. Someone whose motivation for playing is the satisfaction of getting a high score will probably have an Achievement play style, while someone who plays to be part of a community will have a Social gameplay style. However, as the studies reviewed above illustrate, there are additional motivations that do not map directly to a gameplay style factor, such as relaxation, diversion, and coping. Indeed, one person might find focusing on scores and achievements to be relaxing, while another might just find it frustrating. The lack of distinction between style and motivation has obscured these relationships and encouraged attempts to analyse the entire system as a latent variable model, which has in turn caused an important aspect of gaming motivation to be neglected. Stress relief is one of the most commonly reported reasons for playing video games (Reinecke, 2009a; Russoniello, O'Brien,

& Parks, 2009) and has been a key concept in studies of media uses and gratifications (Katz & Foulkes, 1962), yet it appears in very few latent variable models of gaming motivation (e.g. (Demetrovics et al., 2011)).

This curious absence may be explained by the tendency in classical test theory and factor analysis to prefer indicators that have greater within-construct correlation than between-construct correlation (Bollen, 1989), coupled with the assumption that indicators of a construct are interchangeable (Bollen, 1989; Borsboom, Mellenbergh, & Van Heerden, 2003; Holland & Rosenbaum, 1986). This has resulted in items like “I play games to relieve stress” dropping out of principal components or factor analyses, because it loads onto multiple constructs. By considering a dynamic system rather than a latent variable model, which this dissertation does from the perspective of network psychometrics (Borsboom & Cramer, 2013; Borsboom et al., 2003; Schmittmann et al., 2013), we can see how stress recovery maps onto motivations for playing video games through Sonnentag’s Stress Recovery Experience model (Reinecke & Eden, 2017; Sonnentag & Fritz, 2015; Sonnentag & Zijlstra, 2006).

Games and Stress Recovery

Life exists within a relatively narrow spectrum of environmental conditions. A fundamental feature of any living thing is its ability to adapt to changes both inside and outside the organism through the dynamic process of homeostasis. A healthy system oscillates, making continual adjustments from the micro to the macro level to respond to external demands with resilience. However, this response consumes resources which must be replenished, and when external demands outstrip the resources available, the organism begins to suffer.

The physician Hans Selye first described what he called the General Adaptation Syndrome (Selye, 1977), observing that patients with many different diseases and conditions displayed the same set of symptoms associated with “just being sick”. “Stress,” wrote Selye, “is the state manifested by a specific syndrome which consists of all the non-specifically induced changes within a biologic system.” (Selye, 1956, p. 54) These demands needn’t be purely physiological, and needn’t be catastrophic events; indeed, daily hassles have been found to be a better indicator of stress than critical life events (Kanner, Coyne, & Schaefer, 1981; Lazarus, 1993).

Theories of Stress Recovery

Stress recovery is “the process of replenishing depleted resources or rebalancing suboptimal systems” (Sonnentag & Zijlstra, 2006, p. 311). Three main theories of stress recovery have been proposed: the Effort-Recovery Model, Conservation of Resources Theory, and the Stressor Detachment Model (Reinecke & Eden, 2017). In the Effort-Recovery Model, external demands lead to psychological and physiological reactions. These reactions lead to increased arousal or activation to meet the situational demands, but this increased arousal is temporary; once the demands abate, the system re-stabilises. Problematic stress occurs when recovery is not complete or sufficient (Meijman & Mulder, 1998). Conservation of Resources Theory (Hobfoll, 1998) posits that “individuals are motivated to retain, protect and extend their resources. The loss of resources or the perceived danger thereof induces stress." (Reinecke & Eden, 2017, p. 5). Resources may be social-psychological, such as status, self-esteem and mastery, and individuals are motivated to accumulate a "surplus" of resources to buffer against future demands. The Stressor-Detachment Model is related to the Effort-Recovery Model but suggests that stress can occur when the arousal response persists even when the demand is no longer present; recovery involves detachment, or "switching off" this heightened activation (Sonnentag & Fritz, 2015). Sonnentag nicely integrates these theories with their four-dimensional Recovery Experience construct (Sonnentag, Binnewies, & Mojza, 2008; Sonnentag & Fritz, 2007). The recovery experience involves psychological detachment and relaxation as well as mastery and control, nicely linking hedonic and eudaimonic well-being in a robust model that has been replicated in a number of studies (Reinecke & Eden, 2017).

Video games and Sonnentag's stress recovery experience

Several studies have found that interactive media use leads to measurable stress recovery outcomes, including both subjective (vitality, perceived energy) and objective (increased cognitive performance) indicators (Reinecke & Trepte, 2008). Survey studies have suggested that video games can elicit all four facets of recovery and are actively used to recover from stress and strain. Reinecke (2009a) looked specifically at the use of video games for recovery from stressful situations and mental strain. His survey of 1,614 participants found that individuals with emotion-focused coping style showed a greater tendency to use games for recovery than those with a problem-focused coping style, and that games had a stronger stress-buffering effect for individuals with less social support. An additional study found that playing computer games in the workplace improved recovery from work-related fatigue (Reinecke, 2009b). Russoniello et al. (2009) investigated effectiveness of casual video games in decreasing stress, finding that casual video games increased frontal alpha oscillations associated with positive mood, along with decreases in Profile of Mood States subscales for Depression, Anger, and Tension. Interactivity seems to play an important role in stress reduction. Reinecke, Klatt, & Kraemer (2011) found that playing a video game resulted in greater recovery experience than exposure to a video clip; both the game and the video clip resulted in relaxation and psychological detachment, but the video game elicited higher levels of mastery and control experiences.

CHAPTER 2

METHODS AND RESEARCH APPROACH

Overview of the Present Research

It will be helpful at this point to give a chronological overview of the empirical research I conducted, and to define the terminology with which I refer to datasets and studies in this dissertation. I began this journey with the idea of studying the use of virtual spaces in stressful, isolated or confined environments. Many studies have established the positive health and mood effects of natural environments, and a few researchers have begun to investigate the benefits of virtual natural environments (Annerstedt et al., 2013; Berg, Koole, & Wulp, 2003; Kort, Meijnders, Sponselee, & IJsselsteijn, 2006). Role-playing games like *The Elder Scrolls V: Skyrim* have huge open worlds which the player can explore. Most of Skyrim's game world is a pristine northern wilderness, and players spend large amounts of time walking or riding through this wilderness to reach towns, villages, or other points of interest. With a realistic day and night and weather system and a rich ecosystem of flora and fauna, it seems that Skyrim's natural setting might have the same restorative effects established with real and virtual reality versions of nature (Annerstedt et al., 2013; Beute & Kort, n.d., 2014; Pasanen, Tyrväinen, & Korpela, 2014; Roe & Aspinall, 2011). While real life natural settings may be the most effective for stress recovery, they are not always available, especially when the stress itself is caused by an unhealthy physical environment such as an overcrowded living space or an isolated or confined environment. When we do not have control over our physical reality, can we, and should we, escape to a virtual reality instead? There are many situations where virtual worlds could be of tremendous benefit: for patients in long-term care in a hospital, waiting for surgery, or being treated in an intensive care unit (Ampelas, Pochard, & Consoli, 2002); for the elderly or those with limited mobility; or for personnel who are stationed far from home.

After my review of the literature, I realised that before I could investigate the stress-relieving properties of natural spaces in video games, I had to better understand the ways in which gamers play to relieve stress in everyday life. To this end, I conducted an exploratory online questionnaire study of 480 adult self-identified gamers; data collection was complete by February 2016. I will refer to this dataset as EVS1 (Exploring Virtual Spaces). This dataset includes measures of personality, perceived stress, gameplay style and motivations, as well as an optional section specifically about gameplay style in Minecraft which was completed by 138 participants. The EVS1 study showed strong support for the 3-factor model of gameplay style.

In May 2016 I had the opportunity of collaborating with the Autism Research Centre to administer a version of the EVS1 measures to a sample of 106 adults and children with an autism spectrum condition. Given the anecdotal evidence that Minecraft particularly appeals to children with autism, and some empirical evidence that children with autism spend more time playing video games on average than their neurotypical siblings (Marzurek & Wenstrup, 2013), we were interested in exploring the preferences, motivations and gameplay style among autistic gamers. Anecdotal evidence has also suggested the positive effects of Minecraft on the family and social relationships of children with autism, possibly by providing a structured but creative environment. To explore the perceived positive and negative effects of gaming in general and Minecraft in particular, I included open-response questions which were completed by 44 parent-child dyads and 62 adults. The qualitative analysis of these responses is beyond the scope of this dissertation, but is briefly discussed in Chapter 7.

As described in detail in Chapter 5, one of the limitations of the EVS1 study was its lack of an empirically generated measure of reasons for playing video games. To address this, I administered an online open-response questionnaire to 54 adult self-identified gamers, asking them to describe why they decided to play a video or computer game recently, and how they felt before, during, and after playing. Data collection was completed in August 2016, and participant responses were coded by two independent assistants and used to develop a 60-item measure of "Reasons for Playing Video Games". This measure, the RPVG-60, was administered to an online sample of 246 adult gamers in February 2017. An exploratory factor analysis of this data suggested 7 factors, and I selected a subset of items, the RPVG-23, to be included in a large-scale replication of the EVS1 study.

The EVS2 study was completed by 961 adult and adolescent gamers (over the age of 13) and like EVS1 it included measures of personality, perceived stress, living situation, gameplay style, motivations, genre preferences, and an optional Minecraft portion (which was completed by 358 participants). The 3-factor model of gameplay style was replicated in the EVS2 study. However, the anticipated factor structure of the RPVG-23 did not replicate perfectly, having a slightly different 7-factor structure. To investigate this instablity, I returned to the RPVG-60 dataset and conducted a principal components analysis, this time retaining only items with a large primary loading (>.6) and small secondary loadings (<.3). This new subset, the RPVG-32, was administered to a new online sample of 299 adult gamers in January 2018, and a confirmatory factor analysis showed reasonable but not excellent fit.

While gameplay *style* had a stable structure that replicated in every study I conducted, I encountered the same lack of stability of the factor structure of gaming motivations that I had observed in the literature. Eventually it became clear that gaming motivations and gameplay style, while related, describe two distinct systems, and attempts to model gaming motivations as factors obscured the dynamic nature of the system. I realised that important assumptions of latent factor models, that indicators must be locally independent and exchangeable (Bollen, 1989; Borsboom et al., 2003; Holland & Rosenbaum, 1986), are unlikely to apply to motivations and attitudes (Dalege et al., 2016). An alternative and much more useful approach revealed itself in the nascent field of Network Psychometrics.

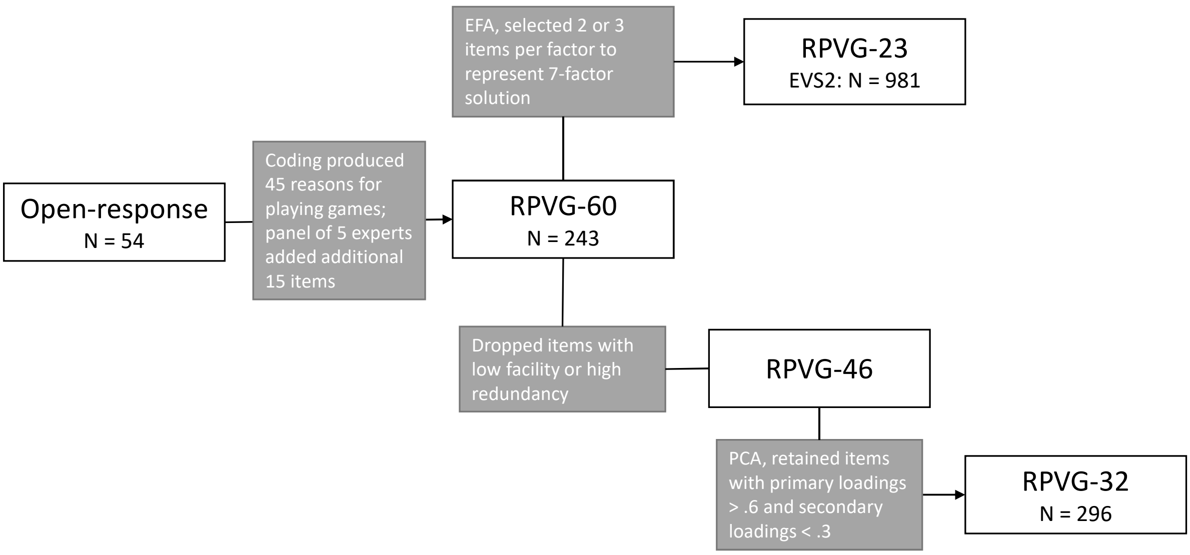

Figure 2.1: Map of the development of the RPVG.

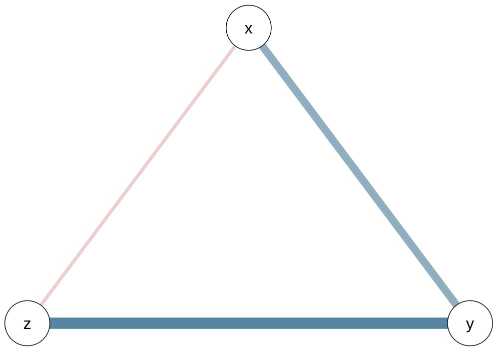

Figure 2.2: A simple correlation matrix plotted as a weighted, undirected network. Blue edges represent positive correlations, red edges negative correlations. Edges are weighted by degree of correlation, with thicker lines representing stronger correlations.

Introduction to Psychological Networks

Many complex systems, from air traffic patterns (Guimera, Mossa, Turtschi, & Amaral, 2005) to the World Wide Web (Barabási, Albert, & Jeong, 2000) to the co-expression of genes (Zhang & Horvath, 2005), can be modelled as networks of interacting elements. Network analysis is most familiar to psychologists in the form of social network analysis, in which individual social actors are "nodes" and associations or interactions between individuals are "edges" connecting the nodes (Scott, 1988; Wasserman & Faust, 1994). By mapping the pairwise interactions in a given social network we can identify features such as particularly influential or central individuals and clusters of individuals who interact frequently with each other.

The unit of analysis of many psychological phenomena such as intelligence, attitudes, and personality traits is the correlation matrix, which is one way of representing pairwise interactions between variables. In recent years, researchers have noticed that these patterns of correlations can be modelled as networks in which nodes represent observed psychological variables and edges are a correlation or other statistical relationship between the variables. In its simplest form, this approach allows for the graphical representation of correlation matrices; patterns can be distinguished visually with greater ease than a correlation table and without the need for variable reduction methods (Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012).

As an example, consider a simple data set with three observations of three variables x, y and z having the correlation matrix:

$$\begin{bmatrix} 1 & 0.5 & -0.19 \\ 0.5 & 1 & 0.76 \\ -0.19 & 0.76 & 1 \end{bmatrix}$$

This correlation matrix can be plotted using the r package *qgraph* (Epskamp et al., 2012) in Figure 2.2. This approach is extremely valuable in exploratory studies of multidimensional data, as patterns can be distinguished visually with greater ease than from a dense numeric table and without the need for variable reduction methods (Epskamp et al., 2012).

Its usefulness goes beyond the visual representation of correlations, however: network psychometrics takes advantage of machine learning-based estimation techniques. Psychological networks based on cross-sectional data and modelled as Figure 2.2 are *undirected* networks. As Epskamp has observed, such undirected networks can be estimated using Pairwise Markov Random Fields (PMRFs), networks in which “edges indicate the full association between two nodes after conditioning on all other nodes in the network;” that is, a partial correlation after controlling for all other connections (Epskamp, 2017, p. 4). A connection between two nodes in such a network suggests that the relationship between the two nodes cannot be explained by any other node, and the absence of an edge between two nodes indicates conditional independence, given the other nodes.

LASSO regularisation

Estimation of the parameters of a network from data inevitably involes sampling variation, resulting in spurious non-zero connections between variables which are conditionally independent (Costantini et al., 2015). Though these spurious connections tend to be very small, they obscure the true structure of the network and can lead to over-interpretation. As Epskamp and Fried point out, one possible solution is to test all partial correlations for statistical signficance and remove the edges which fail to reach significance, but this introduces the problem of multiple testing, which in turn requires a correction (such as a Bonferroni correction) leading to a loss of power (Epskamp & Fried, 2018). Fortunately, Epskamp suggests a more elegant solution in which spurious edges are minimised by a statistical *regularisation* technique, such as the ‘least absolute shrinkage and selection operator’, or LASSO (Tibshirani, 1996). This machine-learning based technique estimates a range of models selected under different values of a tuning parameter λ and selected by optimising the fit of the network to the data, generally by minimising the Extended Bayesian Information Criterion (EBIC) according to a hyperparameter γ, which controls how much the EBIC prefers sparser/simpler models (see Foygel & Drton, 2010). LASSO regularisation with EBIC selection has been shown in simulation studies “to feature high specificity all-around (i.e., not estimating edges that are not in the true network) but a varying sensitivity (i.e., estimating edges that are in the true network) based on the true network structure and sample size” (Epskamp & Fried, 2018, p. 5). Note that use of LASSO regularisation does not affect which variables are selected for inclusion in the model, but only scales the strength of the edge between them, so partial correlation networks estimated without any form of regularisation will have the same general structure, but will appear much “noisier” with the presence of many small, spurious edges.

Centrality

Once the network has been estimated, its characteristics can be further analysed using techniques from graph theory, such as centrality indices to describe the relative importance of nodes in a network (Opsahl, Agneessens, & Skvoretz, 2010). The three most popular measures are *strength*, or how well a node is directly connected to other nodes; *closeness*, or how well a node is indirectly connected to other nodes; and *betweenness*, which indicates how important a node is in the average path between two other nodes.

I apply these techniques in the Reasons for Playing Video Games datasets in Chapter 6 and show that not only is stress relief a central and influential node, but its influence propagates through the network along pathways consistent with Sonnentag's Recovery Experience model (Sonnentag & Fritz, 2007).

Outline

In the following chapter, I present the EVS1 and EVS2 studies in detail, focusing on the 3-factor structure of gameplay style and its correlations with stress, personality, genre preference, and reasons for playing video games. Chapter 4 shows that the 3-factor structure is replicated in the study of gamers with an Autism Spectrum Condition, and investigates correlations between gameplay style and Minecraft play style in the Minecraft portions of the EVS1, EVS2, and ASC studies. In Chapter 5 I describe the development of the RPVG measure in detail, highlighting the effects of different variable reduction and model selection approaches. I present the network analysis of reasons for playing video games in Chapter 6, which first illustrates the centrality of stress relief in the RPVG network, examines the effects of genre preference on the network, and finally explores the "big picture" in a network that includes the latent factors of gameplay style. Chapter 7 discusses a few of the exciting possibilities for future research to explore the hypotheses generated by this dissertation.

Data Collection

Most of the empirical studies presented in this dissertation employ similar procedures of data collection, missing data handling, and statistical analysis; these procedures are discussed in the remainder of this chapter and referred to only briefly in subsequent chapters.

Web-based surveys

To maximise diversity of the samples, participants were recruited through advertisements posted on online gaming forums such as http://community.videogamer.com/forums/, http://forums.steampowered.com/forums/, http://www.minecraftforum.net/forums, http://www.reddit.com/r/gaming/, http://www.reddit.com/r/minecraft. Participants were provided with dynamically-generated feedback based on some of their survey responses. After completing the survey, participants could view their Big Five personality scores along with a brief explanation and were shown one of six "Gaming Personality Types" types loosely based on the hypothesized factor structure and selected based on the participants' genre and playstyle preferences. These six types of Action Hero, Fearless Explorer, Master Strategist, Social Butterfly, Zen Gamer, and Eclectic Gamer were accompanied by a descriptive paragraph and an illustrated portrait (Figure 2.3).

Participants were also shown their scores on each of the five factors measured by the Reasons for Playing Games questionnaire (immersion, escapism, achievement, catharsis, and motivation). Each of the "Gaming Personality Types" are illustrated by custom artwork which can be shared to the participants' Facebook profile.

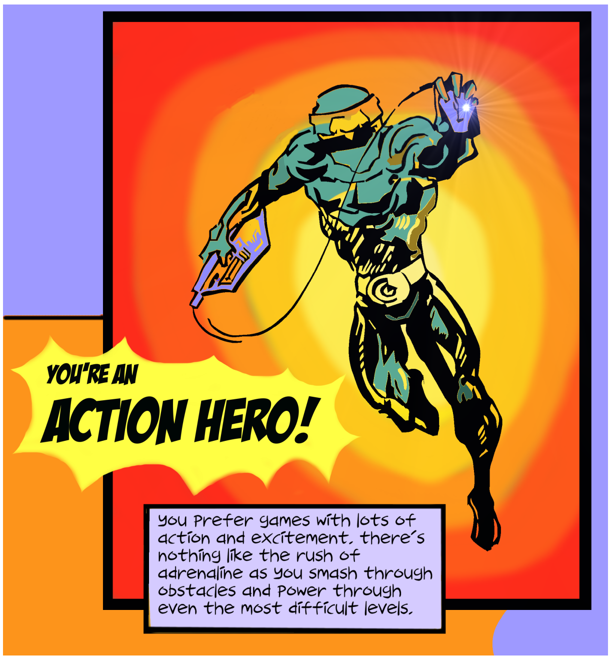

Figure 2.3: Example of the Action Hero gaming personality type from the What's Your Gaming Personality app used in the EVS2 study.

The Steam API

There is a promising new tool which provides objective data to complement self-report, the API of the popular gaming distribution service "Steam."[1] Steam is available as a local client on Windows, Mac and Linux through which users can purchase, download and play games. With a catalogue of nearly 20,000 games and 150 million active users, it provides a unique opportunity to study huge populations of gamers in a readily quantifiable environment. Steam has not received much attention from the scientific community yet, with only a few existing studies employing this vast source of data, such as investigating friendship structures in Steam's social network system (Becker, Chernihov, Shavitt, & Zilberman, 2012) and cheater behaviour (Blackburn et al., 2011).

In my online questionnaire research, I asked those who were Steam users to provide their usernames. Working in collaboration with Dr Richard Mills, the R packages *XML* and *RMySQL* were used to construct web API queries for each participant's Steam ID and then parse the XML results to a MySQL database, which included the number and names of games in the participant's library and the amount of time played in each game overall and in the past two weeks.

The Steam store has a feature in which users tag games with descriptive keywords (such as "atmospheric", "difficult", or "zombies") which help gamers identify new titles they might be interested in. These tags provide a great deal more information than broad genres (such as "action", "adventure", "strategy", etc.) but are not readily available through Steam's API. A Python script[2] was used to scrape the Steam store pages for 15,596 unique games and record the top 21 tags (the most displayed on the Steam store page) for each game in a SQLite database, available on the GitHub repository for this dissertation. These tags provide additional information

[1] https://store.steampowered.com/
[2] Adapted from https://github.com/BronxBombers/Steam-Tags-Database by David Thompson.

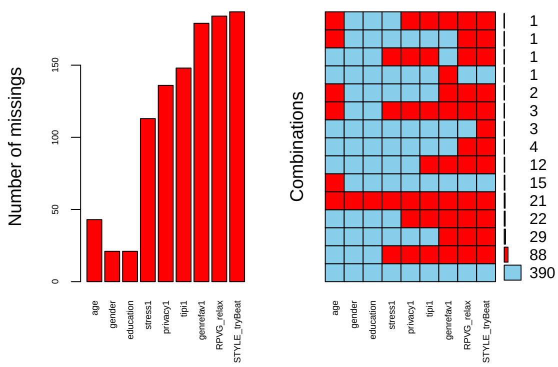

Figure 2.4: Examples of visualisations of missing data variable patterns.

about the games actually played by participants measured to be higher in a particular trait (such as conscientiousness, or immersion gameplay style) in the form of word frequency matrices highlighting commonly occurring tags within a participant's library. These methods are described in more detail in Chapter 3.

Missing Data Handling

As participants were unpaid volunteers recruited primarily through online forums, there were inevitably participants who filled in the first few items of the questionnaire before deciding they were not interested in proceeding, resulting in a large number of partial responses. Participants missing more than 90% of data were simply deleted, but a sizeable proportion of responses still had some missing data. My approach to handling this missing data began with examining the full datasets for outliers and anomalies, deleting data on a case-by-case basis where errors or intentionally nonsensical responses were obvious (Van den Broeck, Argeseanu Cunningham, Eeckels, & Herbst, 2005). I then visually and quantitatively explored the patterns and underlying mechanism of missing data (Templ, Alfons, & Filzmoser, 2012); see Figure 2.5 for some examples of these visualisations. I imputed missing data using the Bayesian approach of multivariate imputation by chained equations (Azur, Stuart, Frangakis, & Leaf, 2011; Rubin, 1976). Multiple imputation is the recommended method for handling complex missing data (Rubin, 1987). There are two general approaches available: joint modelling (JM) and fully conditional specification (FCS), also known as multivariate imputation by chained equations (MICE). JM relies on identification of an appropriate multivariate distribution, while MICE specifies the imputation model on a variable-by-variable basis (Azur et al., 2011).

Eekhout et al. (2014) suggests that for multi-item scales with missing data, multiple imputation at the item level is preferable. Although *mice* is able to impute categorical variables, there was insufficient data to include the demographic variables as predictors, so I imputed only numeric variables, using predictive mean matching.

One of the advantages of the *mice* package is the ability to pool multiple datasets generated during the imputation process, better preserving uncertainty and generally leading to more robust models. Pooling averages the estimates of the complete data model, computing the total variance over the repeated analyses, and the relative increase in variance due to nonresponse and

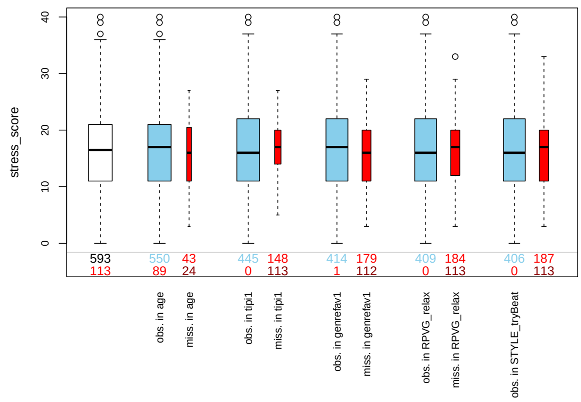

Figure 2.5: Examples of visualisations of missing data variable patterns.

the fraction of missing information (Azur et al., 2011). I used the *miceadds* package function `micombine.cor` to estimate pooled correlation matrices.

Reproducible Research with RStudio and Git

I have tried to be as rigorous as possible throughout my research, particularly in regard to responsible missing data handling and reporting and transparent documentation of decisions. This dissertation is a reproducible document: the code used to run the analyses, plot figures, and output tables is embedded within the text. It was written in RStudio, primarily in R Markdown with some raw LaTeX, and rendered to PDF with knitr (Xie, 2014, 2015, 2018). The project, along with all data files and supplementary materials, is under version control on GitHub and available at https://github.com/jmschallock/SchallockDissertation.

CHAPTER 3

THE FACTOR STRUCTURE OF GAMEPLAY STYLE

Study 1: EVS1

This study examines the relationships between playing styles, genre preferences, personality, and stress, to provide a detailed picture of the motivations and individual differences of video game players. An online survey was completed by 480 adult video gamers. For 150 of the participants, I used the web API of the gaming portal "Steam" to collect detailed data on players' gameplay habits. I identified an underlying factor structure in participants' reasons for playing games and in their gameplay style, and these factors were related to the Big Five personality dimensions.

Methods

Participants

Participants were recruited through advertisements posted on ten online gaming forums including videogamer.com, steampowered.com, minecraftforum.net, and others. I specifically targeted but did not limit advertisements to forums for PC gamers to maximize the number of participants with Steam usernames. Participants were told they could complete the survey if they were at least 18 years old and play any type of digital games, including casual mobile games. Nearly 700 gamers completed at least part of the survey, with complete responses from 419 participants. Of those who indicated, 342 (82%) were male and 70 (17%) were female. The sample ranged in age from 18 to 69, with mean age = 29.52 and median age = 28.0 (SD = 8.28). Forty different countries were represented in the sample, but the most common were the United States (44%) and the United Kingdom (26%). The most common ethnicity was white (70%).

Procedure

Participants were recruited via an advertisement posted to a selection of popular gaming forums. After completing an online consent form and verifying that they were at least 18 years old, participants were shown an online questionnaire hosted on the Psychometrics Centre's platform

"Concerto". The questionnaire included demographic items, measures of perceived stress and privacy, Big Five personality, and items related to their gaming style and preferences.

Those with a Steam account were asked to provide their Steam usernames, which were later used to collect objective data about their gaming behaviour. Participants were informed in advance of how their username would be used and what information would be collected. After completing the main portion of the survey, participants were given the option to complete an additional set of items specifically related to Minecraft. To increase the appeal of the study, custom feedback was provided at the end of the questionnaire.

Stress, Privacy, Personality

Participants completed the 10-item Perceived Stress Scale (PSS-10), which measures perceived stress over the past month (Cohen, Kamarck, & Mermelstein, 1983). To investigate whether gamers experiencing crowded environments were more likely to escape to the virtual space of a video game, I included Grove's 7-item "overcrowding in the home" questionnaire (Grove, 1979). Participants also indicated their current living situation (e.g. "alone", "with parents", "with spouse") and whether their home was located in an urban, suburban or rural area. For those in shared accommodation such as a dormitory or shared flat, participants indicated number of roommates and whether they had a shared or private bedroom.

Mean stress score was 16.71 (SD = 7.64), with a Cronbach's alpha of 0.88. Cohen's (Cohen & Janicki-Deverts, 2012) reported norms in a United States sample were mean = 17.46 (SD = 7.31) for men aged 25-34, so stress levels in our sample were consistent with expectations. Mean imputed privacy score was 10.06 (SD = 5.59, N = 480), with a Cronbach's alpha of 0.85. Pre-imputed mean privacy score was 10.1 (SD = 5.62, N = 457).

To keep the survey as brief as possible, I selected the Ten-Item Personality Inventory (TIPI) as a measure of Big Five personality traits (Gosling, Rentfrow, & Swann Jr, 2003). The imputed Big Five means were 3.15 (SD = 1.61) for extraversion, 4.5 (SD = 1.30) for agreeableness, 4.70 (SD = 1.40) for conscientiousness, 4.67 (SD = 1.58) for emotional stability, and 5.13 (SD = 1.12) for openness. Imputed Big Five results yielded low Cronbach's alphas of 0.75 for extraversion, 0.35 for agreeableness, 0.58 for conscientiousness, 0.76 for emotional stability, and 0.39 for openness; Gosling (Gosling et al., 2003) notes that the Ten-Item Personality Inventory was not designed with coefficient alphas in mind, but rather as a very short instrument that optimises validity and measures broad constructs rather than individual facets.[1]

One sample t-tests indicate that our sample of gamers are lower in openness (t (479) = -7.44, $p < 0.001$), higher in emotional stability (t (479) = 4.53, $p < 0.001$), lower in agreeableness (t (479) = -3.26, $p = 0.001$), lower in extraversion (t (479) = -11.264, $p < 0.001$), and not significantly different in conscientiousness (t (479) = 1.42, $p = 0.16$) compared to population norms (Gosling, Rentfrow, & Potter, n.d.). Our gamers are slightly lower in stress than Cohen's (2012) sample (t (479) = -2.1364, $p = 0.03$).

[1] See https://gosling.psy.utexas.edu/scales-weve-developed/ten-item-personality-measure-tipi/a-note-on-alpha-reliability-and-factor-structure-in-the-tipi/

Gameplay style

Participants were asked to think back over their gaming experiences in the past month and indicate how often they would agree with each of 12 statements I designed to capture the facets of Achievement ("I try hard to beat the games I play"), Immersion ("I play games that make me feel as if I am somewhere else"), and Socialising, ("I prefer to play against the computer rather than against other humans"), using a 5-point Likert scale (never/rarely/sometimes/often/always).

Table 3.1: Variable name and full text of the 12 gameplay style variables.

Variable	Item Text
randomStrangers	I play online with random human players I don't know in real life.
onlineTeam	I play online with the same group of guild or team members, who I don't know in real life.
tryBeat	I try hard to beat the games I play.
feelSomewhereElse	I play games that make me feel as if I am somewhere else.
dontGiveUp	Even when I get frustrated with a game, I don't give up.
preferComputer	I prefer to play against the computer rather than against other humans.
scoresAch	I pay close attention to scores and achievements.
emotionsStay	The emotions I feel while I'm playing stay with me after I finish playing.
logicStrategy	The logic and strategy of a game is very important to me.
charactersFeelReal	The characters in the game feel like real people.
moreComfortableInGame	I am more comfortable in the game world than in real life.
gamePhysicalSpace	The game environment feels like a real physical space.

Items and variable names for the gameplay style measure are listed in Table 3.1.

Gameplay Frequency

Participants were asked to think about all the different digital games they play, including PC and console games as well as casual browser-based games or games on their smartphone. Total frequency of gameplay was indicated by number of days played in the past month, whether days on which gameplay occurred were evenly spread throughout the month or clustered in groups (i.e. only on weekends or in binges), and by number of hours played in the past week.

More than half the participants played more than 20 days in the past month, and 176 (37%) played 25-30 days. However, a significant proportion played much less frequently, with 86 (18%) playing on 10 days or less in the past month, and 47 (10%) playing on 5 days or less. Most participants' gaming was evenly spread throughout the month, and number of gameplay days was not related to clustering. Number of hours played in the past week was close to a uniform distribution from a minimum of less than 1 hour to a maximum of more than 21 hours. 110 participants (22%) reported playing less than 3 hours in the past week, 100 (21%) played more than 20 hours. Participants who reported a clustered pattern of gameplay days tended to play less than those who reported an evenly spread pattern ($r = -0.21$, $p < 0.001$).

Steam API After removing users with private profiles or unrecognised usernames, I was able to collect API data for 99 of the 152 participants who provided usernames. I collected the number and names of all games each participant owned, including names and playtime for games which had been played in the past two weeks. Our sample comprised a wide variety of games libraries, with numbers ranging from 3 to 1,825 and an average of 251. Many participants owned games

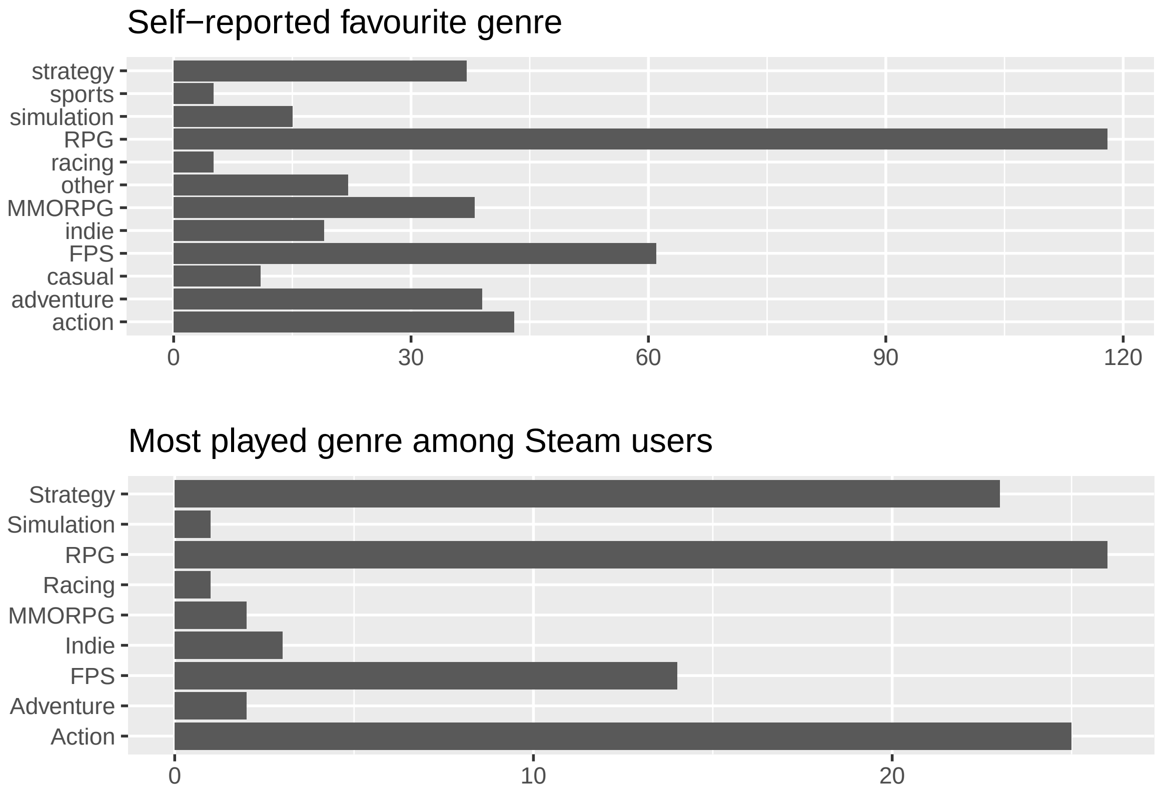

Figure 3.1: Favourite genre.

which they had never played; number of played games ranged from 2 to 1,054 and an average of 130. This is unsurprising, given the availability of games "bundles" and consistent with O'Neill, Vaziripour, Wu, & Zappala (2016)'s observation of "collector behaviour" (p. 87). Gamers had played an average of 1,841 hours in total, again with a wide range of 25 to 10,621 hours. Average playtime in the past two weeks was 26 hours and ranged from 3 minutes to 140 hours.

Genre preference

I used the list of 11 genres from the Steam store, as they were likely to be familiar to most gamers: Action, Adventure, First-Person Shooter, Casual, Indie, Massively multiplayer, Racing, RPG, Simulation, Sports and Strategy, and added an additional "Other" category in which participants could enter an open response. Participants were asked to select the three genres they spent the most time playing, in order of preference. I used the Steam-based genres to facilitate comparison of the self-report measure with the API data, though some of these genres are extremely broad (e.g. Action) or arguably not genres at all (e.g. Indie). As shown in Figure 3.1, Role-Playing Game (RPG; e.g. Skyrim) was the most commonly reported favourite genre, followed by First-Person Shooter (FPS; e.g. Call of Duty), Action, and Massively Multiplayer Online Role-Playing Game (MMORPG; e.g. World of Warcraft). For the subset of participants who provided Steam API data, the most commonly played genres were Action, RPG, Strategy, and FPS.

To investigate the validity of the self-reported favourite genre measure (that is, whether a participant's self-reported favorite genre was actually their most played genre), I performed a chi-square measure of association and computed Cramer's V. The chi-square test indicated that the self-reported favourite genre and the actual most played genre were not independent, χ^2 (2, N = 118) = 165.66, p < .001). Cramer's V had a value of 0.419, indicating a strong relationship between the two variables.

Table 3.2: Correlations of Genre with Personality

	A	N	C	O	E
action	-0.04	0.01	-0.03	-0.10*	0.00
adventure	-0.04	-0.02	0.00	0.00	-0.01
RPG	-0.05	-0.01	0.05	-0.10*	-0.06
FPS	-0.03	0.01	0.02	0.00	0.00
strategy	0.00	-0.03	0.00	0.06	0.00
MMORPG	0.03	0.06	0.01	0.03	0.08
casual	0.02	-0.05	-0.07	-0.01	-0.02
simulation	0.10*	0.04	0.02	0.11*	0.02

Self-reported genre was uncorrelated with perceived stress score and lack of privacy. Gamers who preferred simulation games were slightly higher in agreeableness and openness, while RPG and action gamers were slightly lower in openness.

Gaming motivations

Participants were asked to indicate how often each of a list of 16 statements, written by the researcher to capture common reasons for playing games, described their reasons for playing games on a 5-point Likert scale (never/rarely/sometimes/often/always). The statements were completions of the phrase "I play games___". The full list of items is shown in Table 3.3.

Table 3.3: Variable name and full text of the gaming motivations variables.

Variable	Item Text
relax	to relax.
energized	to feel energized.
reducestress	to reduce stress.
distract	to distract myself from real life.
fun	for fun.
socialize	to socialize.
challenge	to challenge myself.
excite	for excitement.
angry	when I'm feeling angry.
bored	when I'm feeling bored.
sad	when I'm feeling sad.
noreason	for no particular reason.
creative	to be creative.
express	to express myself.
different	to be someone different from who I am in real life.
explore	to explore somewhere new.

The generic reasons "for fun" and "when I'm feeling bored" were included for completeness and unsurprisingly were among the most commonly reported reasons for playing; Olson (2010)'s survey of children found the most common reason for playing was "it's just fun", followed by "it's exciting" and "something to do when bored." However, 78% of participants reported that they often or always play games to relax, 60% reported often or always playing to reduce stress, and 62% reported playing to explore somewhere new. In contrast, 64% of participants reported often or always playing for excitement, 43% to challenge themselves, and only 14% when they are feeling angry. Only 21% of participants reported playing primarily to socialize. These results indicate that gamers consciously play to relax and reduce stress, and that distraction from real life and exploring new places are important reasons for playing games. To investigate whether these various reasons for playing had an underlying structure, I conducted an exploratory factor analysis.

Results

Factor analysis of gameplay style

Factorability of the correlation matrix I used several methods to assess the factorability of the data. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (Cerny & Kaiser, 1977) for the pooled correlation matrix was 0.72; values close to zero indicate the presence of large partial correlations compared to the sum of correlations, so KMO values closer to 1 are preferable, with a recommended minimum of 0.6 (Dziuban & Shirkey, 1974). Bartlett's test of sphericity was significant (χ^2 (66) = 1065.336, p < .001), indicating that the correlation matrix differs significantly from the identity matrix and therefore that the variables are related to each other (Bartlett, 1951).

Determining number of factors to retain To determine the number of factors to retain, I employed parallel analysis of Monte Carlo simulations (using the `fa.parallel` function in the *psych* package), reproducibility across multiple factor-extraction methods, comparison of goodness-of-fit indices such as the Tucker Lewis Index of factoring reliability (Tucker & Lewis, 1973) and the RMSEA index, and interpretability of factors.

A common criticism of scree plot analysis is its subjective nature, generally relying on the researcher's visual inspection to determine the location of the "elbow". The *nFactors* package (Raiche, 2010) includes two non-graphical solutions to the scree test: an acceleration factor (AF) and the optimal coordinates index (OC). If λ_i is the i^{th} eigenvalue and LS_i is a location statistic such as the mean:

The acceleration factor corresponds to the second derivative of the curve and represents a numerical solution to the "elbow":

$$n_{AF} = If \equiv [(\lambda_i \geq LS_i) and\ max(AF_i)]$$

The optimal coordinates are the extrapolation of the previous eigenvalue by a linear regression using the last eigenvalue coordinates and the $k + 1$ eigenvalue coordinates:

$$n_{OC} = \sum_i [(\lambda_i \geq LS_i) \cap (\lambda_i \geq (\lambda_{i\ predicted})]$$

As shown in Figure 3.2, the acceleration factor and optimal coordinates suggest a three-factor solution. Additionally, parallel analysis of the pooled correlation matrix with simulated data

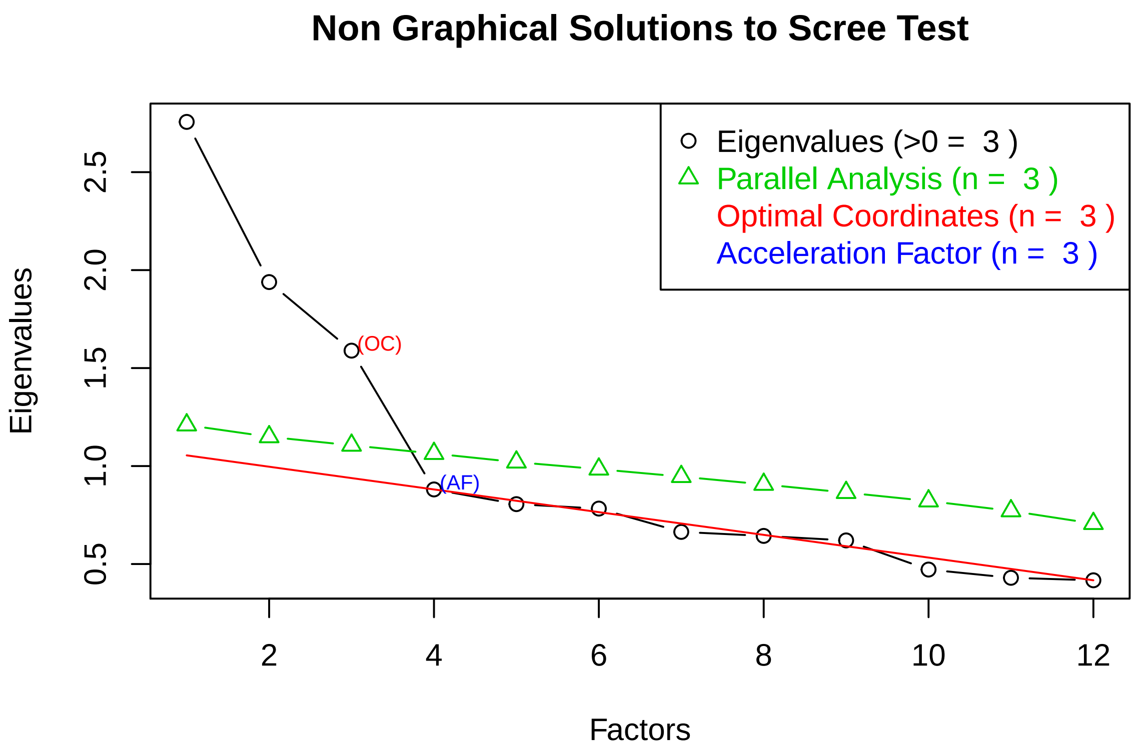

Figure 3.2: Parallel Analysis of gameplay style correlation matrix.

indicate a three-factor solution. This is consistent with the evidence in the literature suggesting the three factors of Immersion, Achievement and Socialising (Graham & Gosling, 2013; Yee, 2007).

Factor analysis Several factor analysis algorithms were considered, including maximum likelihood estimation, principal axes factor analysis, and minimum residual (Ordinary Least Squares) factor analysis (Harman & Jones, 1966). All factor extraction methods produced similar results; factor correlations after performing Fisher's r-to-z transformation were 1.00, 1.00 and 1.00 for each of the three methods. Additionally, Tucker's factor congruence coefficients were 1.00, 1.00 and 1.00 for each method (Lorenzo-Seva & Ten Berge, 2006).

The loadings of the oblimin-rotated maximum likelihood estimation factor analysis are shown in Table 3.4. The three-factor solution had a Tucker Lewis Index of 0.97 and an RMSEA index of 0.031. The Immersion factor accounted for 13% of the variance and represented emotional engagement and spatial presence within games. The social factor accounted for 12% of the variance and represented online multiplayer gaming, playing with strangers, and preferring to play against humans rather than the computer. The Achievement factor accounted for 11% of the variance and represented a focus on logic, strategy, scores and achievements, persevering even when a game was frustrating and generally trying to “beat” the game.

Table 3.4: Factor loadings of gameplay style

Variable	ML2	ML1	ML3	h2	u2	com
randomStrangers	0.01	**0.88**	0.01	0.79	0.21	1.00
onlineTeam	0.09	**0.56**	0.01	0.33	0.67	1.05
tryBeat	-0.01	-0.01	**0.77**	0.59	0.41	1.00
feelSomewhereElse	**0.54**	0.02	-0.03	0.29	0.71	1.01
dontGiveUp	0.01	0.02	**0.60**	0.36	0.64	1.00
preferComputer	0.20	**-0.53**	0.00	0.30	0.70	1.28
scoresAch	0.05	0.20	**0.37**	0.21	0.79	1.61
emotionsStay	**0.50**	-0.01	0.16	0.29	0.71	1.20
logicStrategy	0.18	0.06	0.30	0.14	0.86	1.72
charactersFeelReal	**0.76**	-0.08	0.01	0.57	0.43	1.02
moreComfortableInGame	**0.51**	0.14	-0.21	0.31	0.69	1.49
gamePhysicalSpace	**0.67**	0.06	0.03	0.46	0.54	1.02
SS loadings	1.91	1.46	1.26			
ML2	1.00	0.09	0.09			
ML1	0.09	1.00	0.15			
ML3	0.09	0.15	1.00			

NOTE: Factor loadings > |.3| are printed in **bold.**

Correlations with genre

The gameplay style factors showed a consistent and logical pattern of correlations with self-reported genre preference. Gamers higher on the Immersion factor were more likely to prefer adventure games, both singleplayer roleplaying (RPG) and massively multiplayer online roleplaying games (MMORPG) and were less likely to prefer casual games. Social gamers on the other hand were less likely to prefer singleplayer roleplaying games but significantly more likely to prefer MMORPGs. Achievement-oriented gamers were more likely to prefer first-person shooters (FPS) and MMORPGs but less likely to prefer casual games. Interestingly, the strategy genre was uncorrelated with either Immersion or Achievement, with only a slight negative correlation with the Social factor. As one of the highest-loading items on the Achievement factor was "The logic and strategy of a game is very important to me" I would have expected to see a relationship between the strategy genre and the Achievement factor. Similarly, the simulation and action genres were unrelated to all three factors, perhaps due to being broad genre labels that encompass many different types of games affording a variety of play styles.

Table 3.5: Correlations of Genre with Style Factors

	Immersion	Social	Achievement
action	-0.05	-0.01	-0.03
adventure	0.11*	-0.06	-0.01
RPG	0.10*	-0.17***	-0.03
FPS	-0.01	0.16**	0.10*
strategy	-0.08	-0.11*	0.00
MMORPG	0.12*	0.30***	0.11*
casual	-0.17***	-0.11*	-0.11*
simulation	0.01	0.01	-0.09

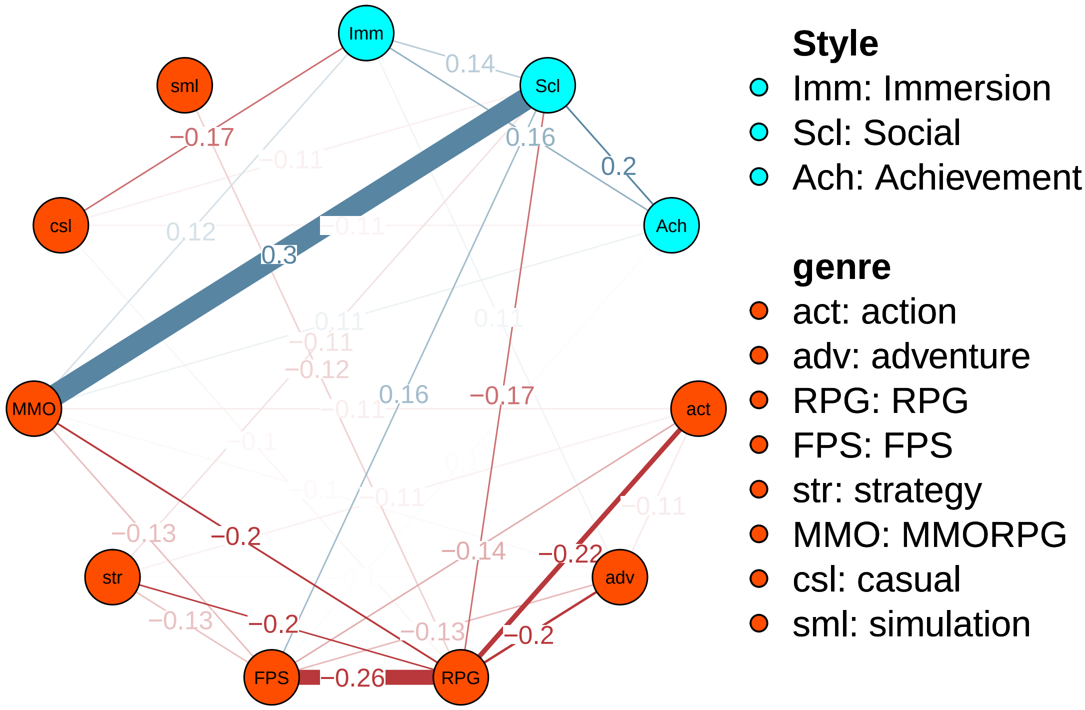

Figure 3.3: Network plot of correlations of Style factors and genre.

Correlations with reasons for playing games

As shown in Table 3.6 and graphically in Figure 3.4, the three style factors were related to the 16 reasons for playing games. Gamers with higher scores on Immersion were especially likely to play games to be someone different from who they are in real life ($r = 0.43$, $p < 0.001$), to distract themselves from real life ($r = 0.25$, $p < 0.001$), to reduce stress ($r = 0.21$, $p < 0.001$) and when feeling angry ($r = 0.19$, $p < 0.001$) or sad ($r = 0.22$, $p < 0.001$). Immersion is not limited to escapism or playing to cope with a negative emotion: there were also significant correlations with playing to explore somewhere new ($r = 0.46$, $p < 0.001$), for excitement ($r = 0.30$, $p < 0.001$), to be creative ($r = 0.26$) and to express oneself ($r = 0.32$). Immersion was related to some degree to all of the reasons for playing except “for fun”, “to socialize”, “for a challenge”, “when I’m feeling bored” and “for no particular reason.”

Social gamers were, unsurprisingly, most likely to play games to socialize ($r = 0.47$, $p < 0.001$), and Achievement-oriented gamers tended to play for a challenge ($r = 0.48$, $p < 0.001$). A few of the reasons for playing games were correlated with all three style factors: “to feel energized” and “for excitement” had similar sized correlations with the three factors. “To relax” and “to express myself” correlated with all three but most strongly with Immersion. Only two reasons for playing had negative associations, both with the Achievement factor: Achievement-oriented gamers were slightly less likely to play to distract themselves from real life ($r = -0.11$, $p < 0.05$) and to be someone different from who they are in real life ($r = -0.13$, $p < 0.01$). Most of the emotion-related reasons for playing were correlated with the Immersion and Social factors but not the Achievement factor: playing to reduce stress, when feeling angry, and when feeling sad

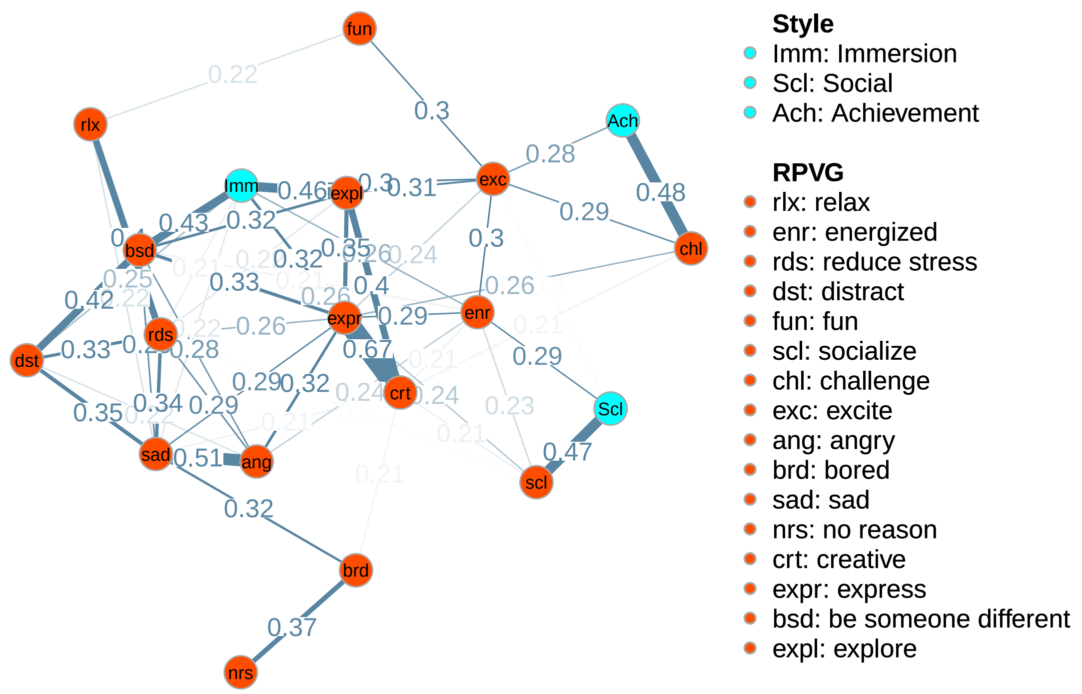

Figure 3.4: Network plot of correlations of Style factors and Reasons for Playing Video Games.

Table 3.6: Correlations of reasons for playing games with Style Factors

	Immersion	Social	Achievement
relax	0.19***	0.10*	0.12**
energized	0.26***	0.29***	0.17***
reduce stress	0.21***	0.15***	0.04
distract	0.25***	0.13**	-0.11*
fun	0.09	0.06	0.18***
socialize	0.09	0.47***	0.17***
challenge	0.08	0.11*	0.48***
excite	0.30***	0.20***	0.28***
angry	0.19***	0.14**	0.04
bored	0.07	0.14**	0.05
sad	0.22***	0.16***	0.00
no reason	0.08	0.09*	0.03
creative	0.26***	0.08	0.09*
express	0.32***	0.19***	0.15**
be someone different	0.43***	0.11*	-0.13**
explore	0.46***	0.01	0.15**

were unrelated to Achievement.

Factor analysis of reasons for playing games

Factorability of the correlation matrix As with the gameplay style variables, I used several methods to assess factorability of the Reasons for Playing Games variables. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy for the pooled correlation matrix was 0.74. Individual item scores ranged from a low of 0.61 for "I play games for fun" to a high of 0.85 for "I play games to socialize"; both the overal MSA and the item MSA scores were above the recommended minimum of 0.6 for factorability (Cerny & Kaiser, 1977; Dziuban & Shirkey, 1974). Bartlett's test of sphericity was significant (χ^2 (120) = 1621.98, p < .001), indicating that the correlation matrix differes significantly from the identity matrix and therefore that the variables are related to each other (Bartlett, 1951).

Determining number of factors to retain To determine the number of facors to extract, I again employed the *nFactors* package (Raiche, 2010), which provides graphical and non-graphical solutions to the scree test, as described in detail in the factor analysis for gameplay style. Unfortunately, the results were not as clear-cut as they were for the gameplay style analysis, though given the lack of consensus on a factor structure for gaming motivations discussed in the literature review, this is unsurprising. Figure 3.5 shows the non graphical solutions provided by the *nFactors* package, while Figure 3.6 shows the parallel analysis of Monte Carlo simulations using the `fa.parallel` function in the *psych* package. Taken together, these tests suggest extracting up to six factors.

Factor analysis As Figure 3.5 suggested 4, 5 or 6 factors, I examined the solutions for each sequentially to assess factor interpretability and compare goodness-of-fit indices. In order to be significantly different from the null model, MacCallum et al. suggest that the RMSEA should be below 0.1, ideally below 0.05, and the Tucker Lewis Index should be greater than 0.9 (MacCallum, Browne, & Sugawara, 1996). The 4-factor solution had a Tucker Lewis Index of 0.74 and an RMSEA of 0.08; all four factors were interpretable, with the first relating to negative affect (playing when sad and angry) and escapism/distraction, the second relating to creativity, exploration, and self-expression, the third relating to excitement, challenge, fun, and energy, and the fourth relating to relaxation and stress relief.

The 5-factor solution had a better fit than the 4-factor solution, with a TLI of 0.825 and RMSEA index of 0.069. The same "creativity", "energy" and "relaxation" factors were present in the 5-factor solution, and the negative affect factor split into an "angry/sad" factor and a "distract/different" factor.

The 6-factor solution had the best fit, with a TLI of 0.952 and RMSEA index of 0.036. The 7-factor solution was examined, but did not yield further interpretable factors; the "distract/different" factor merely split into two factors with loadings approaching 1.00.

As the analysis was exploratory, oblimin rotation was employed to improve factor interpretability and allow correlation between factors. Oblimin-rotated maximum likelihood factor loadings for

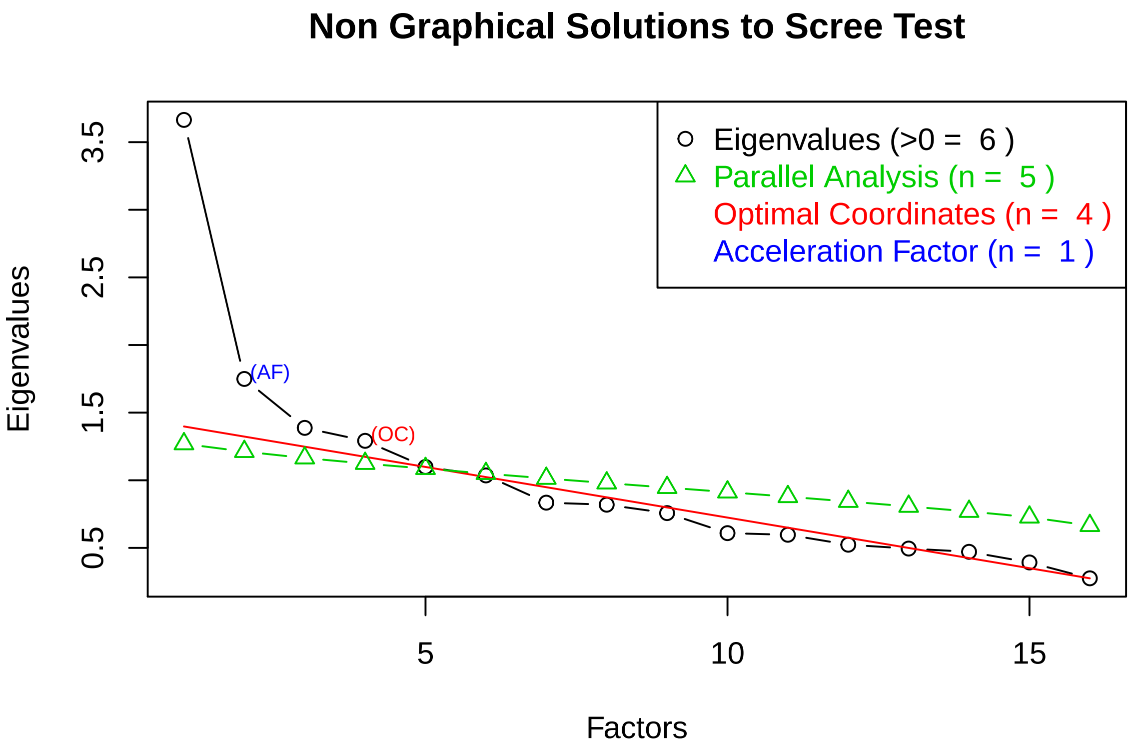

Figure 3.5: Non graphical solutions to scree test of reasons for playing games.

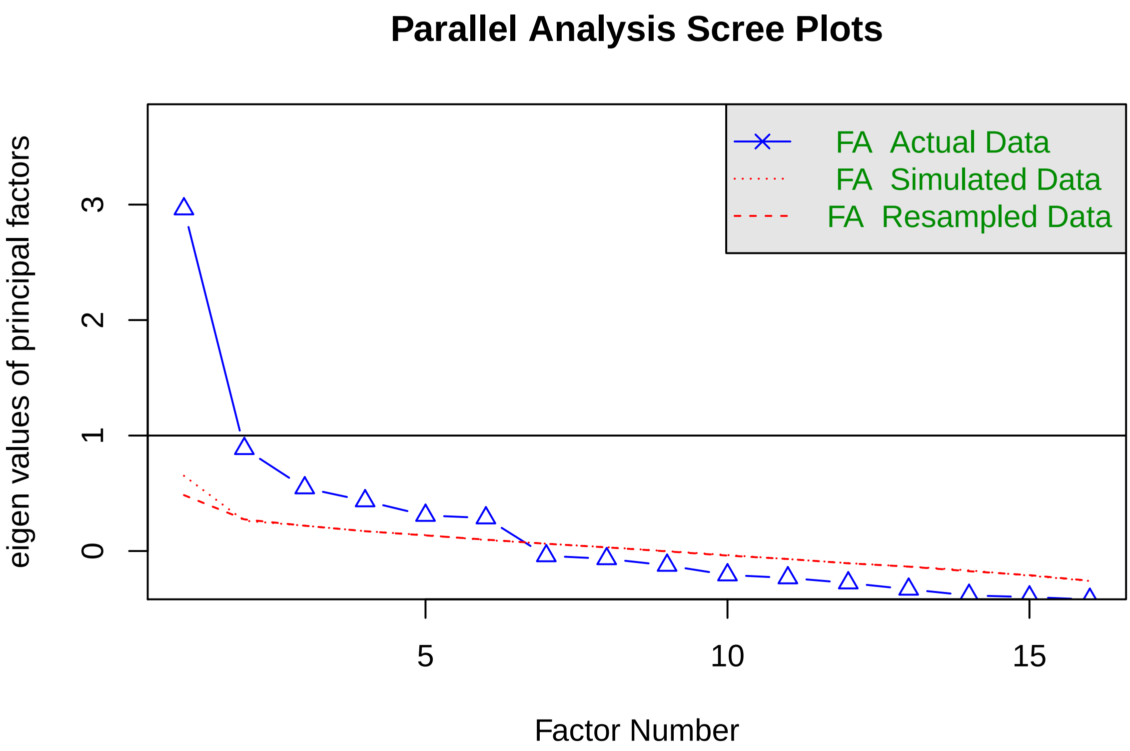

Figure 3.6: Parallel Analysis of reasons for playing games correlation matrix.

the 6-factor solution are presented in Table 3.7.

Table 3.7: Factor loadings of gameplay motivations.

Variable	ML1	ML2	ML5	ML4	ML6	ML3	h2	u2	com
relax	0.01	-0.01	**0.63**	-0.01	-0.07	-0.04	0.37	0.63	1.03
energized	0.10	0.07	0.06	**0.35**	0.22	-0.09	0.25	0.75	2.21
reducestress	0.05	0.01	**0.65**	-0.01	0.16	-0.03	0.51	0.49	1.14
distract	-0.13	**0.45**	0.26	-0.09	0.10	0.10	0.35	0.65	2.11
fun	0.01	-0.19	0.28	**0.36**	-0.28	0.11	0.35	0.65	3.70
socialize	0.17	-0.13	0.11	0.19	0.18	0.05	0.16	0.84	4.66
challenge	0.19	-0.05	-0.15	**0.38**	0.12	-0.04	0.20	0.80	2.11
excite	-0.05	0.04	-0.02	**0.76**	0.02	0.04	0.57	0.43	1.02
angry	0.05	0.03	0.05	0.05	**0.73**	0.03	0.60	0.40	1.04
bored	0.03	0.00	-0.03	0.00	0.01	**0.80**	0.65	0.35	1.01
sad	0.03	0.10	0.24	-0.01	**0.45**	0.25	0.50	0.50	2.30
noreason	-0.06	0.03	-0.08	0.07	0.07	**0.45**	0.21	0.79	1.20
creative	**0.92**	-0.04	0.00	-0.06	-0.04	0.05	0.81	0.19	1.02
express	**0.69**	0.10	0.02	0.11	0.17	-0.07	0.66	0.34	1.24
different	0.02	**0.85**	-0.04	0.02	0.00	0.00	0.73	0.27	1.01
explore	0.30	0.29	0.17	0.21	-0.26	0.06	0.40	0.60	4.47
SS loadings	1.64	1.18	1.19	1.17	1.15	1			
ML1	1.00	0.27	0.25	0.30	0.19	0.22			
ML2	0.27	1.00	0.21	0.17	0.36	0.17			
ML5	0.25	0.21	1.00	0.23	0.21	0.22			
ML4	0.30	0.17	0.23	1.00	0.03	0.22			
ML6	0.19	0.36	0.21	0.03	1.00	0.17			
ML3	0.22	0.17	0.22	0.22	0.17	1.00			

NOTE: Factor loadings > |.3| are printed in **bold.**

A positive affect "Creative" factor with loadings of "I play games to express myself", "to explore somewhere new" and "to be creative" emerged first and accounted for 9.5% of the variance. The second factor had high loadings of "I play games to distract myself from real life", "to be someone different from who I am in real life" and "to explore somewhere new". "I play games to reduce stress" did not load onto this factor, but factor scores were positively correlated with Perceived Stress Score, with r = 0.45 ($p < 0.001$). The third factor was characterised by boredom, playing when feeling sad, and playing for no particular reason. The fourth factor had high loadings on playing for excitement, fun, energy, and challenge.

Playing "to reduce stress" loaded only onto the fifth factor, which also had a high loading of playing "to relax" and lower loadings of "to distract from real life", "for fun", and "when feeling sad". Factor scores correlated only weakly with Perceived Stress Score, r = 0.15 ($p < 0.001$). The sixth and final factor was the only one to have negative loadings and was primarily characterised by playing when feeling angry and playing when feeling sad. Factor scores correlated significantly with Perceived Stress Score, r = 0.39 ($p < 0.001$).

The six Reasons for Playing Games factors are correlated with the Style factors in Table 3.8 and graphically in Figure 3.7. Immersion significantly correlated with all six factors, most highly with Escape (r = 0.50, $p < 0.001$). The Escape factor was slightly negatively correlated with Achievement (r = -0.09, $p < 0.05$) and uncorrelated with the Social style factor.

Table 3.8: Correlations of Style Factors with RPVG Factors

	Achieve	Social	Immersion
Create	0.14**	0.14**	0.32***
Escape	-0.09*	0.07	0.50***
Bored	0.06	0.17***	0.15**
Excite	0.38***	0.22***	0.33***
PosStress	0.09*	0.19***	0.31***
NegStress	0.00	0.21***	0.18***

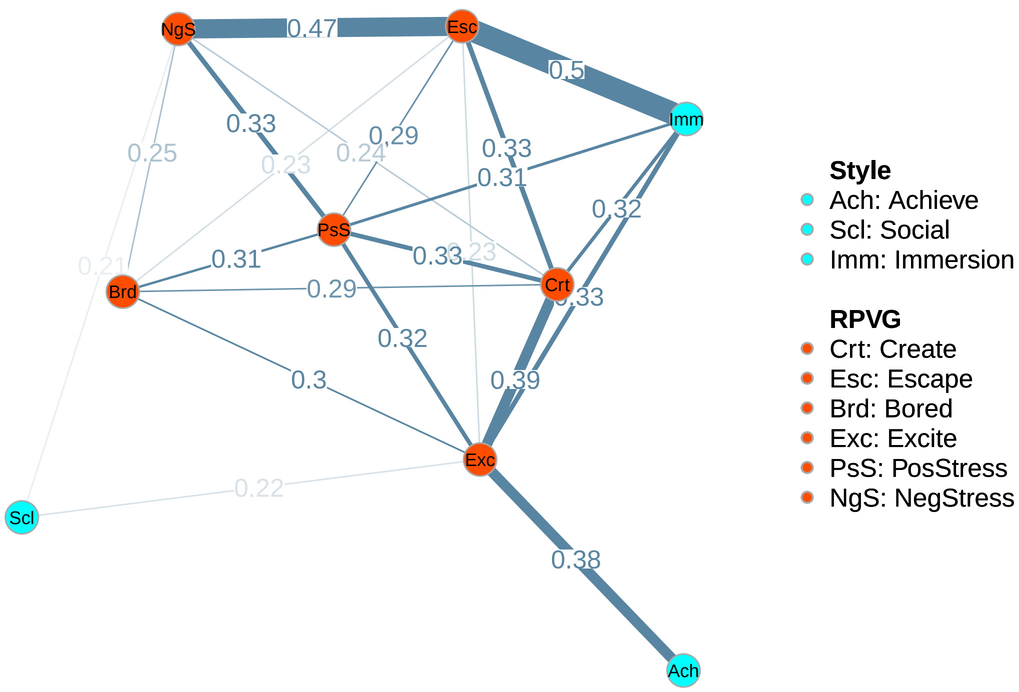

Figure 3.7: Correlations of Style factors with the 6 Reasons for Playing Games Factors.

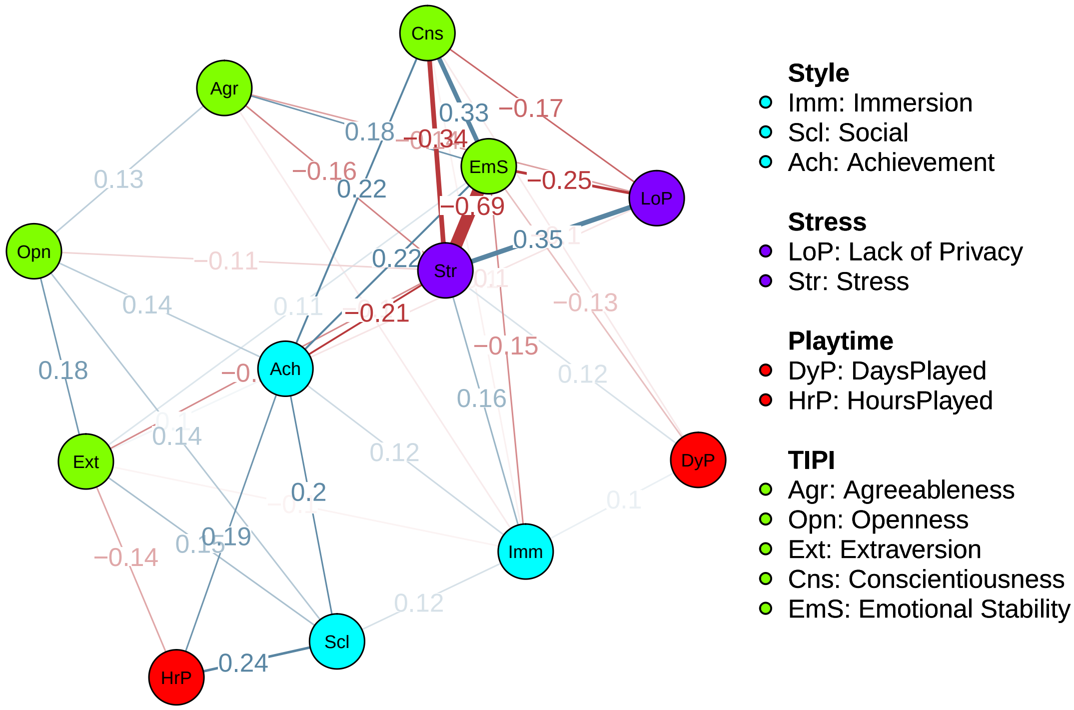

Figure 3.8: Graphical representation of correlations between gameplay style factors, stress, privacy, play time, and personality.

Correlations with stress, privacy, personality

Immersion was slightly positively correlated with stress (r = 0.16, p < 0.01) and negatively with emotional stability (r = -0.15, p < 0.01). Social gaming style was positively correlated with hours played in the past week (r = 0.24, p < 0.01) and positively correlated with both openness and extraversion. Achievement gaming style was negatively correlated with stress, and lack of privacy, and positively correlated with number of hours played, conscientiousness and emotional stability. These correlations are presented in Table 3.9 and as a graphical network in Figure 3.8.

Table 3.9: Correlations of Stress, Privacy, Gameplay Frequency and Personality with Style Factors

	Immersion	Social	Achievement
Lack of Privacy	0.08	0.07	-0.10*
Stress	0.16***	0.02	-0.21***
Days Played	0.10*	0.07	0.00
Hours Played	0.08	0.24***	0.19***
Agreeableness	-0.10*	-0.09	0.07
Openness	-0.02	0.14**	0.14**
Extraversion	-0.10*	0.15**	0.10*
Conscientiousness	-0.10*	-0.02	0.22***
Emotional Stability	-0.15***	0.00	0.22***

Summary

Study 1 investigated the relationships between gameplay style, motivation, genre preference, personality and stress in an online exploratory study of 480 adult gamers. The most commonly reported favourite genre was role-playing game, and self-reported genre preference was validated by objective data on owned and played games in participants' Steam libraries. Genre preference was largely unrelated to the Big Five personality traits.

The most common motivation for playing games was simply "for fun," followed by "to relax" and "when I'm feeling bored". 60% of participants reported often or always playing games to reduce stress, with only 43% playing to challenge themselves and 21% to socialise. A factor analysis of the 16 reasons for playing games suggested six underlying factors of Create, Escape, Bored, Excite, Relax and Catharsis. The Relax and Catharsis factors were both associated with stress relief in different ways. The Relax factor had a high loading of the item "I play games to reduce stress" but a smaller positive correlation with perceived stress score ($r = 0.15$, $p < 0.001$). The Catharsis factor had high loadings of playing when feeling angry or sad but a weak loading of "reduce stress", and significant correlation with perceived stress score ($r = 0.39$, $p < 0.001$).

This study showed strong evidence in support of a three-factor structure of gameplay style. These factors do not appear to be genre artefacts but instead represent distinct approaches to playing games. Even with non-orthogonal oblimin rotation, the factors were only slightly correlated with each other, with r values of 0.09, 0.09, and 0.15. The factor structure was additionally supported by a logical pattern of correlations with reasons for playing games, in which gamers with an Immersion play style tended to play for escapism, distraction, and fantasy/adventure, while social gamers played for excitement, energy, and self-expression. Achievement-oriented gamers played to have a challenge and were less likely than social and immersion-focused gamers to play for distraction and escapism.

Gamers experiencing more stress in their daily lives were more likely to have Immersion-focused rather than Social or Achievement play styles, and playing games to reduce stress was associated with the Immersion and Social factors but not with the Achievement factor. Achievement-oriented gamers tended to be lower in stress, higher in conscientiousness and emotional stability, and also played more than Immersion-focused gamers. This provides tentative evidence against the argument that gamers who play to relieve stress or escape from worries are playing excessively.

Appendix A: EVS1 Study

Table 3.10: Descriptive statistics of the gameplay style variables

Statistic	N	Mean	St. Dev.	Min	Max
randomStrangers	480	2.91	1.25	1	5
onlineTeam	480	2.20	1.22	1	5
tryBeat	480	3.70	1.04	1	5
feelSomewhereElse	480	3.40	1.06	1	5
dontGiveUp	480	3.57	0.91	1	5
preferComputer	480	3.33	1.19	1	5
scoresAch	480	2.76	1.19	1	5
emotionsStay	480	3.13	1.01	1	5
logicStrategy	480	3.78	1.01	1	5
charactersFeelReal	480	2.70	1.09	1	5
moreComfortableInGame	480	2.54	1.26	1	5
gamePhysicalSpace	480	2.53	1.14	1	5

Table 3.11: Descriptive statistics of the reasons for playing games variables.

Statistic	N	Mean	St. Dev.	Min	Max
relax	480	3.89	0.88	1	5
energized	480	2.65	1.08	1	5
reducestress	480	3.49	1.01	1	5
distract	480	3.30	1.16	1	5
fun	480	4.52	0.70	1	5
socialize	480	2.46	1.16	1	5
challenge	480	3.20	1.14	1	5
excite	480	3.62	0.94	1	5
angry	480	2.25	1.09	1	5
bored	480	3.64	0.98	1	5
sad	480	2.56	1.11	1	5
noreason	480	3.33	1.04	1	5
creative	480	2.66	1.17	1	5
express	480	2.36	1.13	1	5
different	480	2.51	1.35	1	5
explore	480	3.53	1.09	1	5

Table 3.12: Correlation matrix of gameplay style variables. *** p < .001, ** p < .01, *p < .05

	rStr	onlTeam	tryBt	flSomeElse	dntGiveUp	prfComp	scrAch	emStay	logStr	chFlRl	mComInGame
randomStrangers											
onlineTeam	0.51***										
tryBeat	0.10*	0.06									
feelSomewhereElse	0.07	0.07	0.05								
dontGiveUp	0.11*	0.12**	0.47***	-0.02							
preferComputer	-0.45***	-0.26***	-0.05	0.03	-0.01						
scoresAch	0.23***	0.16***	0.33***	-0.02	0.19***	-0.14**					
emotionsStay	0.06	0.08	0.13**	0.26***	0.14**	0.05	0.17***				
logicStrategy	0.11*	0.08	0.23***	0.12*	0.20***	-0.03	0.19***	0.22***			
charactersFeelReal	0.01	0.07	0.05	0.42***	0.07	0.18***	0.02	0.39***	0.13**		
moreComfortableInGame	0.14**	0.15***	-0.11*	0.30***	-0.10*	0.05	0.04	0.26***	0.03	0.33***	
gamePhysicalSpace	0.12**	0.12**	0.06	0.35***	0.07	0.04	0.15**	0.34***	0.16***	0.52***	0.35***

Table 3.13: Correlation matrix of gaming motivations variables. *p < .05

	rlx	enrg	rdstress	dst	fun	soc	ch	exc	ang	brd	sad	nrs	crea	exp	diff
relax															
energized	0.10*														
reducestress	0.40*	0.20*													
distract	0.14*	0.17*	0.33*												
fun	0.22*	0.10*	0.13*	-0.10*											
socialize	0.09	0.23*	0.20*	0.03	0.14*										
challenge	-0.03	0.19*	0.01	0.03	0.08	0.17*									
excite	0.08	0.30*	0.12*	0.05	0.30*	0.15*	0.29*								
angry	0.10*	0.24*	0.29*	0.22*	-0.15*	0.18*	0.09*	0.11*							
bored	0.06	0.05	0.12*	0.15*	0.14*	0.15*	0.06	0.16*	0.16*						
sad	0.22*	0.18*	0.34*	0.35*	0.00	0.19*	0.07	0.13*	0.51*	0.32*					
noreason	-0.01	0.13*	0.05	0.14*	0.04	0.03	0.06	0.12*	0.12*	0.37*	0.17*				
creative	0.11*	0.21*	0.20*	0.06	0.11*	0.21*	0.21*	0.14*	0.17*	0.21*	0.21*	0.07			
express	0.15*	0.29*	0.26*	0.13*	0.06	0.24*	0.26*	0.24*	0.32*	0.16*	0.29*	0.05	0.67*		
different	0.07	0.21*	0.15*	0.42*	-0.11*	0.04	0.06	0.15*	0.28*	0.12*	0.29*	0.08	0.18*	0.33*	
explore	0.19*	0.14*	0.22*	0.16*	0.20*	0.15*	0.16*	0.31*	0.05	0.17*	0.16*	0.09	0.40*	0.35*	0.32*

Study 2: EVS2

The objective of Study 2 was to replicate the factor structure of gameplay style found in Study 1 in a new, larger sample of adults and children aged 13-17 in the autumn of 2017.

Methods

Participants

A total of 961 self-identified gamers (869 males, 77 females, 15 non-binary, other or unspecified) responded to advertisements posted to online gaming forums and shared through social media. Age ranged from 13 to 88, with an average of 24 (SD = 7.13). Fifty-seven countries were represented in the sample, most commonly the United States (60%) and the United Kingdom (11%).

Procedure

The procedure was largely the same as Study 1: participants were recruited via advertisements on online gaming forums and social media to complete a series of questionnaires, provide their Steam usernames if applicable and were given feedback about their "Gaming Personality Type" (as discussed in the previous chapter). Instead of the Ten Item Personality Inventory, this study used the ten-item Big Five Inventory (BFI 10, Rammstedt & John (2007)) which has established norms for an adolescent population.

Stress, Privacy, Personality

Imputed stress score had a Cronbach's alpha of 0.89, and a mean of 17.01 (SD = 7.64). Imputed privacy score had a Cronbach's alpha of 0.86, and a mean of 9.53 (SD = 5.8). Imputed Big Five scores yielded Cronbach's alphas of 0.6 for extraversion, 0.39 for agreeableness, 0.45 for conscientiousness, 0.64 for neuroticism, and 0.29 for openness. Imputed means were 2.46 (SD = 1.03) for extraversion, 3.38 (SD = 0.93) for agreeableness, 3.09 (SD = 0.84) for conscientiousness, 2.87 (SD = 1.13) for neuroticism, and 3.62 (SD = 0.91) for openness.

Gameplay Frequency and Console

Of the 888 participants who indicated, 60% (522) reported generally playing games for several hours per day. 39% (344) played a few hours per week, 2% (19) played only a few times per month, and 3 participants reported playing games very rarely. 65% of participants played on a computer, 19% on a PlayStation, 12% on an Xbox, and 3% on a mobile device such as a phone, tablet, or handheld console.

Steam API I was able to parse 201 of the 247 participants who provided Steam usernames. Those 201 gamers had played 6,540 different games, representing a huge amount of diversity

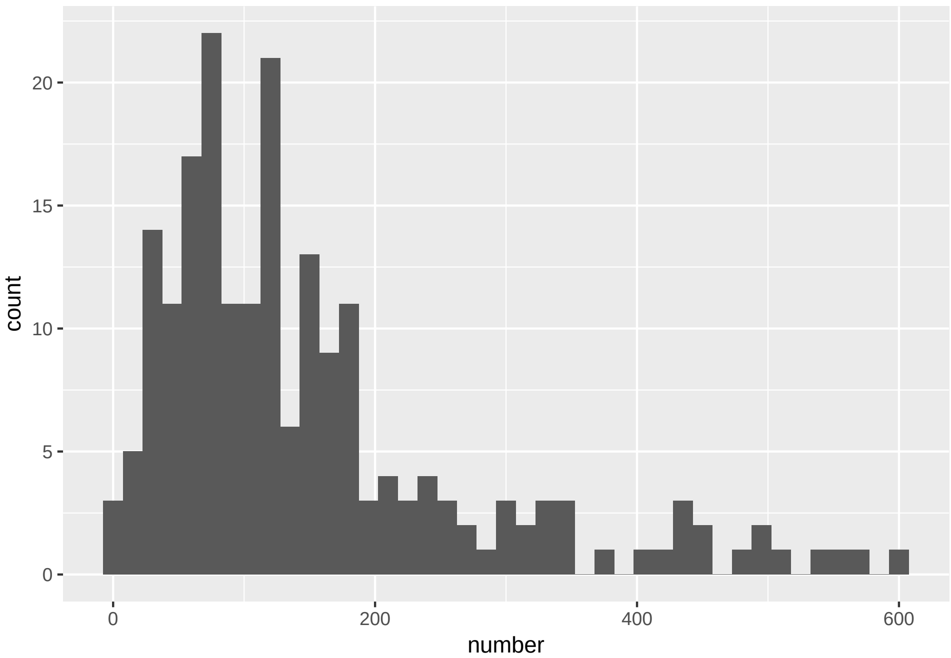

Figure 3.9: Histogram of total number of games played per participant.

both across and within participants. The number of games played per participant ranged from 5 to 603, with an average of 151 (SD = 124) (see Figure 3.9), and they played an average of 5 games in a two-week period (SD = 4.62), ranging from 1 to a maximum of 33. Overall playtime in a two-week period had an average of 10.95 hours (SD = 28.03), ranging from a minimum of about 5 minutes to a maximum of 286.85. As O'Neill et al. (2016) have observed, it is unlikely that gamers actually spent that much time playing, as Steam logs playtime if the game is active in the background (p. 89).

Genre Preference

Participants indicated their genre preference by selecting how often they played each of 13 genres on a 5-point scale ranging from "never" to "always". In addition to the 11 genres from the Steam store included in Study 1, we added sandbox (creative games with an element of undirected building, such as Minecraft) and distinguished between adventure games with and without combat.

Figure 3.10 shows the distribution of means of genres for the two age groups of adult (age > 18, N = 828) and adolescent (age 13-17, N = 133). Sports and casual games were the least popular for both groups, and shooter, sandbox, adventure with combat, and roleplaying were the most popular. Adults were more likely than adolescents to prefer roleplaying games, but there were no other significant differences between the age groups.

Non-violent adventure games were preferred by those higher in Agreeableness and Openness (r = 0.11). Puzzle games were less preferred by high Extraversion gamers (r = -0.12) and more preferred by high Openness gamers (r = 0.09). Extraversion was not correlated with massively multiplayer but was slightly correlated with sports games (r = 0.14).

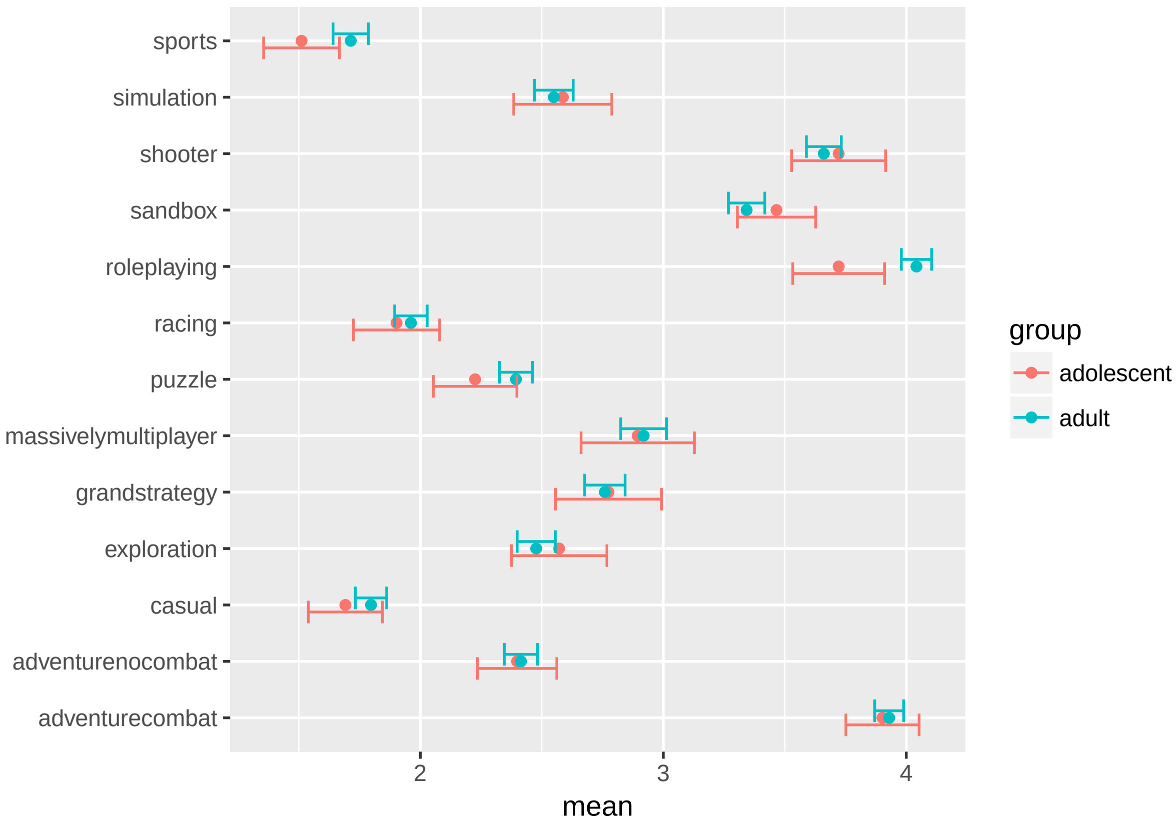

Figure 3.10: Means of genre preference

Table 3.14: Correlations of Big Five Personality with Genre

	E	A	C	N	O
adventure with combat	0.01	0.00	0.05	-0.06*	0.09**
shooter	0.03	0.00	0.01	-0.03	-0.01
simulation	0.00	-0.05	0.03	0.05	-0.01
casual	-0.04	0.03	0.03	0.03	0.08*
adventure, no combat	-0.03	0.11***	0.03	0.07*	0.12***
sports	0.12***	-0.03	0.02	-0.05	-0.01
grand strategy	-0.05	-0.03	-0.04	-0.04	0.03
massively multiplayer	0.07*	0.05	0.01	-0.08*	-0.05
exploration	-0.01	0.03	0.04	0.02	0.08**
puzzle	-0.11***	0.02	0.07*	0.04	0.10**
roleplaying	-0.07*	-0.02	-0.01	-0.04	0.05
sandbox	-0.05	-0.06	-0.03	0.02	0.00
racing	0.03	0.02	0.09**	0.02	0.04

Gaming Motivations

This study employed a new set of 23 items measuring reasons for playing games. The items were developed by a multistage process described briefly here and in more detail in the next chapter. I first recruited 54 self-identified gamers via online gaming forums and asked them to think back to the last time they played a video game and to describe why they decided to play a game just then, in their own words and in as much detail as they could.

The responses were coded by two assistants with experience playing video games, with the aim of capturing the breadth of responses rather than tight intercoder reliability. The coders identified 45 distinct reasons for playing games (see Chapter 5 for more detail about the coding process and development of the RPVG). These 45 reasons were then presented to a new panel of 5 individuals with experience playing video games, who were asked to suggest any additional reasons they felt were not represented, resulting in an additional 15 reasons.

The final bank of 60 items (see Appendix) was then administered to an online sample of 243 adult self-identified gamers recruited via gaming forums. These participants were presented with the 60-item matrix, in randomised order, with the answer options "never, rarely, sometimes, often, always." Participants were encouraged to answer every question, but were able to leave items blank if they wished. All items were formatted as completions of the phrase "I play games. . . " for example: "to be somewhere else for a while; to reduce stress by doing something relaxing; when I'm feeling angry."

Table 3.15: Variable name and full text of the RPVG-23.

Variable	Item Text
adventure	to have an adventure
aggression	to work out aggression
creative	to be creative
energized	to feel energized
distractworries	to distract myself from worries
playfriends	to play with my friends
adrenaline	for the adrenaline rush
challenge	for a challenge
onlinecommunity	to be part of an online community
reward	as a reward to motivate me for doing something productive
skill	to master a skill
story	to experience the story
breakfromwork	for a break from work or school
control	to feel in control
compete	to compete
different	to be someone different from who I am in real life
ach	to get all the achievements
stressed	when I'm feeling stressed
inspire	for inspiration
violence	because I enjoy the violence
experienceworld	to experience the world of the game
ignoresurroundings	to ignore my surroundings
relax	to relax

After dropping items with low facility (that is, with means approaching the extreme scores) and high redundancy (Pearson's $r > 0.7$) I conducted an exploratory factor analysis of the

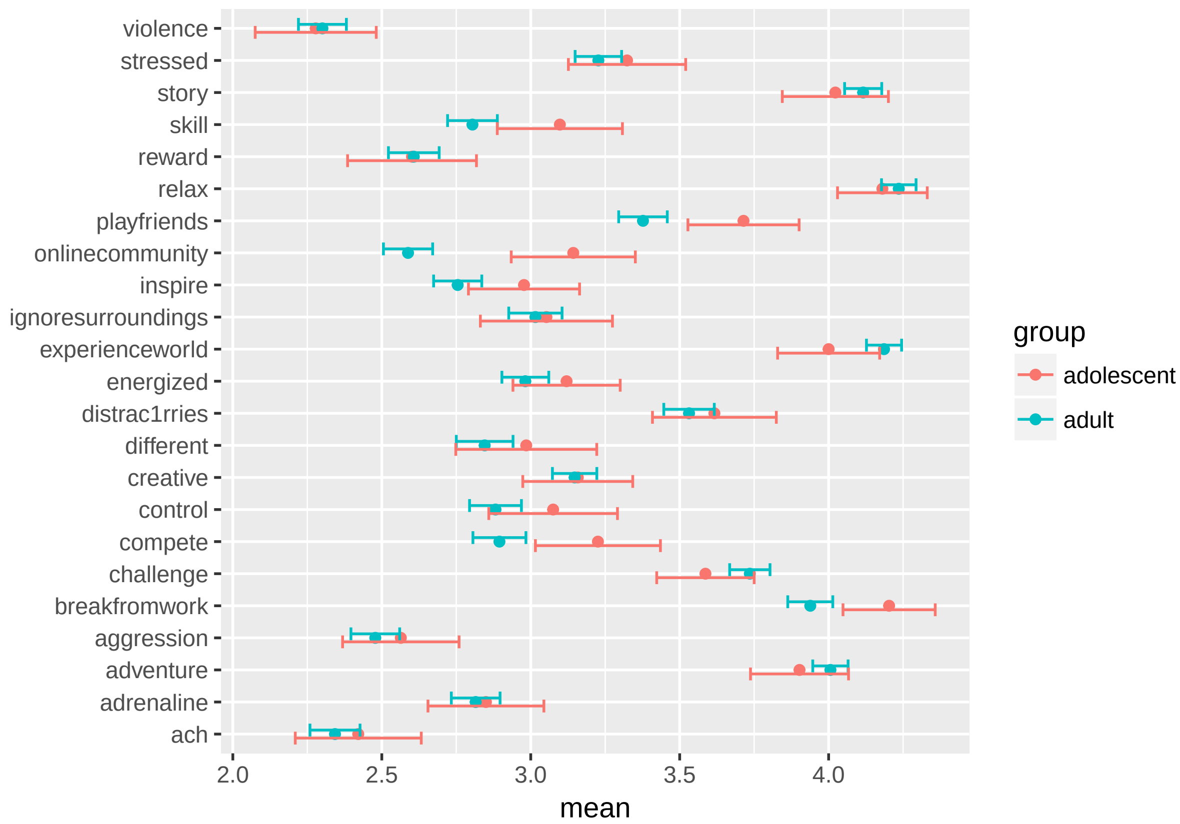

Figure 3.11: Means of Reasons for Playing Video Games items.

remaining items, which suggested a 7-factor solution consisting of escape/distraction, adventure, social/team, achievement, aggression/violence, motivation/reward, and creative/building. To keep the measure as short as possible, I selected only two or three items to represent each factor, resulting in a final set of 23 items.

As shown in Figure 3.11, the most common reasons for playing were to relax and to experience the world and story of the game. The least common reasons were "because I enjoy the violence", "to work out aggression" and "to get all the achievements". Adolescents were more likely to play to be part of an online community, to compete, and to play as a break from work or school.

Results

Factor analysis of gameplay style

As with the previous factor analyses, I employed several methods to assess factorability and numbers of factors to retain. Bartlett's test of sphericity was significant (χ^2 (66) = 2038.185, p < .001) (Bartlett, 1951). The pooled correlation matrix had a Kaiser-Meyer-Olkin measure of sampling adequacy score of 0.74 (Cerny & Kaiser, 1977). Examination of the scree plot, non-graphical solutions, and parallel analysis of the pooled correlation matrix with simulated data all indicated three factors (Figure 3.12).

The three-factor solution had a good fit, with a Tucker Lewis Index = 0.912 and RMSEA = 0.057. As with Studies 1 and 2, the three factors which emerged were Immersion, accounting

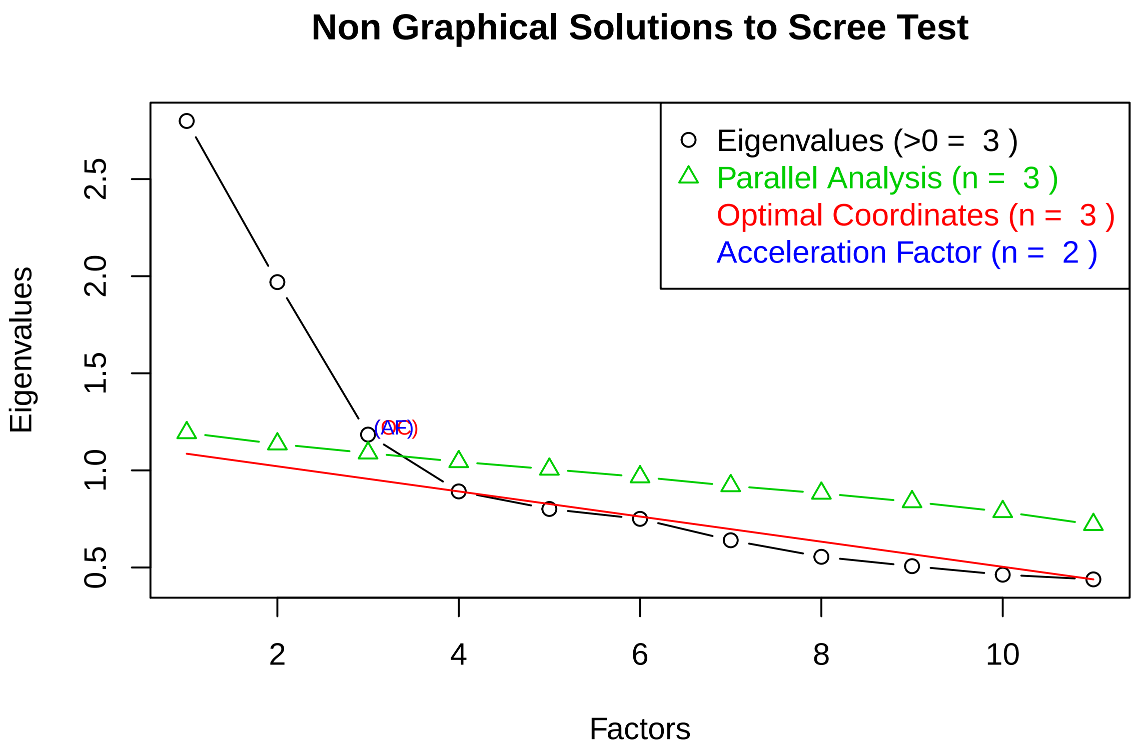

Figure 3.12: Scree Test and parallel analysis of gameplay style correlation matrix, Study 3.

Table 3.16: Factor loadings of gameplay style.

Variable	ML2	ML1	ML3	h2	u2	com
randomStrangers	0.07	0.03	**0.74**	0.56	0.44	1.02
tryBeat	-0.02	**0.85**	-0.02	0.71	0.29	1.00
feelSomewhereElse	**0.55**	0.10	-0.04	0.35	0.65	1.08
dontGiveUp	0.05	**0.54**	0.05	0.32	0.68	1.03
preferComputer	0.13	0.03	**-0.65**	0.45	0.55	1.08
scoresAch	0.05	**0.33**	0.21	0.19	0.81	1.74
emotionsStay	**0.47**	0.12	0.06	0.26	0.74	1.16
logicStrategy	0.09	**0.33**	0.03	0.14	0.86	1.18
charactersFeelReal	**0.72**	0.01	-0.07	0.53	0.47	1.02
moreComfortableInGame	**0.59**	-0.06	0.09	0.33	0.67	1.07
gamePhysicalSpace	**0.71**	-0.04	0.01	0.50	0.50	1.01
SS loadings	1.97	1.32	1.06			
ML2	1.00	0.25	-0.09			
ML1	0.25	1.00	0.22			
ML3	-0.09	0.22	1.00			

NOTE: Factor loadings > |.3| are printed in **bold.**

for 18% of the variance, Achievement, with 12% of the variance, and Social, with 10% of the variance. Factor loadings are presented in Table 3.16.

Correlations with genre

As shown in Table 3.17 and graphically in Figure 3.13, gamers with higher scores on the Immersion factor were more likely to prefer adventure games with and without combat, roleplaying, exploration, and sandbox games. Immersion was slightly correlated with preference for the simulation genre, which was unrelated to the other two factors. Social gamers were more likely to prefer shooters and, unsurprisingly, massively multiplayer games (r = 0.43); all other genres were either uncorrelated or had negative correlations (casual, adventure without combat, puzzle and roleplaying). Achievement-oriented gamers preferred adventure games with combat only, as well as shooters, and showed slight preferences for grand strategy, massively multiplayer, puzzle and roleplaying games.

Table 3.17: Correlations of Genre with Style Factors

	Immersion	Social	Achievement
adventurecombat	0.26***	-0.02	0.29***
shooter	0.07*	0.28***	0.23***
simulation	0.10**	-0.03	-0.01
casual	-0.01	-0.16***	-0.09**
adventurenocombat	0.17***	-0.13***	0.06
sports	-0.09**	0.01	0.01
grandstrategy	0.05	-0.01	0.12***
massivelymultiplayer	0.04	0.43***	0.14***
exploration	0.20***	-0.05	0.04
puzzle	0.10**	-0.11***	0.09**
roleplaying	0.24***	-0.11***	0.19***
sandbox	0.16***	-0.04	-0.02
racing	0.00	0.00	0.02

Correlations with RPVG

Table 3.18 shows the correlations between the three gameplay style factors and reasons for playing games. Figure 3.14 shows these correlations as a graphical network. The Social style factor has strong connections to the "online community" and "compete" nodes, but overall has fewer connections than Achievement, which has a strong link with "challenge" but many weaker nodes. The Immersion factor is part of a cluster that includes exploration, adventure and being someone "different from who I am in real life". These patterns of correlations can be explored further through an exploratory factor analysis, which I describe in the following section, and also as a network, which is discussed in Chapter 6.

Factor analysis of reasons for playing

The RPVG-23 was designed to capture the seven factors of escape/distraction, adventure, social, achievement, aggression, motivation and creativity; an exploratory factor analysis was performed to investigate whether these factors replicated in the EVS2 sample.

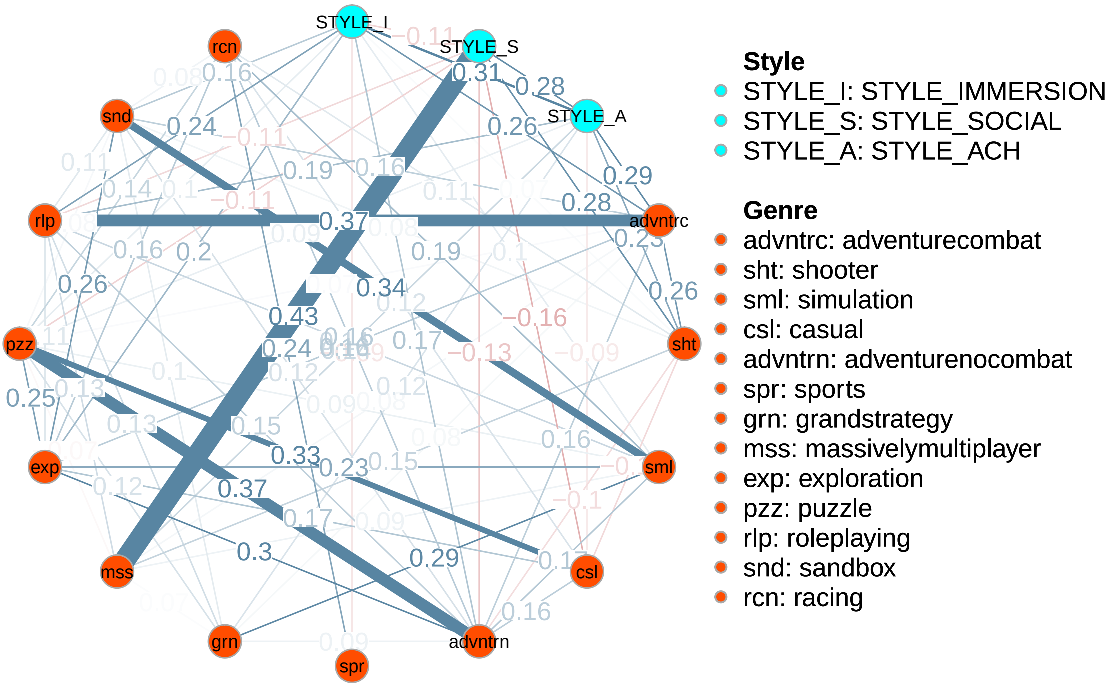

Figure 3.13: Correlations of Style Factors with genre. N=961

Table 3.18: Correlations of Style Factors with Reasons for Playing Games, N=961

	Immersion	Social	Achievement
adventure	0.42***	-0.13***	0.24***
aggression	0.23***	0.08*	0.13***
creative	0.27***	-0.02	0.11***
energized	0.29***	0.09**	0.23***
distrac1rries	0.34***	0.03	0.09**
playfriends	-0.04	0.40***	0.15***
adrenaline	0.24***	0.23***	0.27***
challenge	0.09**	0.28***	0.48***
onlinecommunity	0.10**	0.51***	0.19***
reward	0.23***	0.09**	0.19***
skill	0.20***	0.24***	0.32***
story	0.37***	-0.13***	0.24***
breakfromwork	0.19***	0.06	0.12***
control	0.41***	0.02	0.15***
compete	0.03	0.51***	0.37***
different	0.53***	-0.06	0.11***
ach	0.13***	0.16***	0.35***
stressed	0.26***	0.01	0.10**
inspire	0.36***	-0.02	0.13***
violence	0.25***	0.10**	0.14***
experienceworld	0.46***	-0.12***	0.22***
ignoresurroundings	0.39***	-0.02	0.07*
relax	0.15***	0.00	0.15***

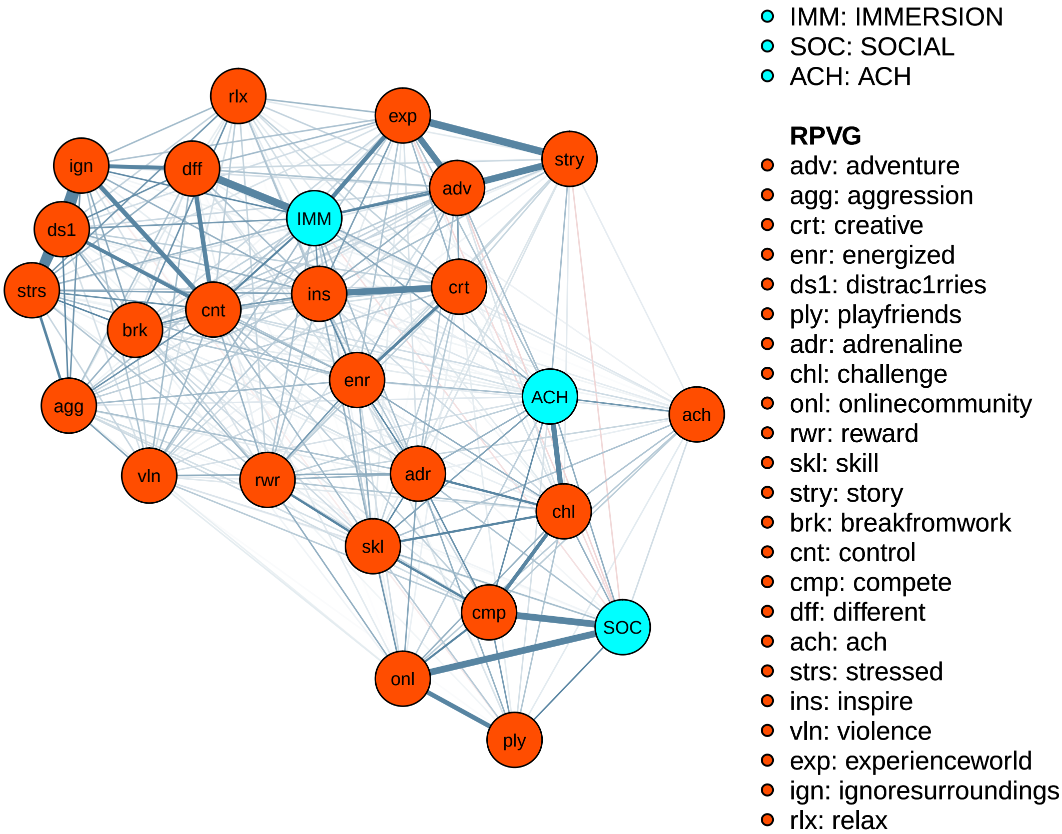

Figure 3.14: Graphical representation of correlations between the gameplay style factors and reasons for playing games.

Unsurprisingly, the correlation matrix had a high Kaiser-Meyer-Olkin Measure of Sampling Adequacy (MSA) of 0.85, above the recommended minimum of 0.6 (Dziuban & Shirkey, 1974), and Bartlett's test of sphericity was significant (χ^2 (253) = 6509.17, p < .0001).

Similarly to the EVS1 study, the non-graphical solutions to the scree test (Figure 3.15) suggested four to seven factors, while the parallel analysis suggested seven factors (Figure 3.16). Each solution was examined in turn, and the 7-factor structure was the most interpretable and had the best goodness-of-fit indices, with a Tucker Lewis Index of factoring reliability = 0.914 and RMSEA index = 0.048; oblimin-rotated factor loadings are reported in Table 3.19.

Playing for achievement, skill development, and competition converged into a single factor; similarly, playing for inspiration, to be creative and to feel energized loaded onto a single factor. The Adventure/Story/Immersion factor appeared as in the RPVG-46, as did the Social factor. In contrast to the RPVG-46, the initial "stress relief" factor encompasses varying levels of energy and affect, folding together relaxation, distraction, playing to work out aggression and playing to take a break from work or school. The item "I play games when I'm feeling stressed" did not cross-load on multiple factors but loaded strongly onto this initial factor. Some of the other items with high loadings on Factor 1 also loaded onto Factor 6, which appears to capture a Fantasy/Escapism facet characterised by playing to feel in control and to be someone different from who one is in real life. While the "when I'm feeling stressed" item loaded only onto Factor 1, scores on both Factors 1 and 6 were correlated significantly with Perceived Stress Scale score, with r = 0.45 (p < 0.001) and r = 0.42 (p < 0.001), respectively. The two factors are strongly correlated with each other at r = 0.63 (p < 0.001).

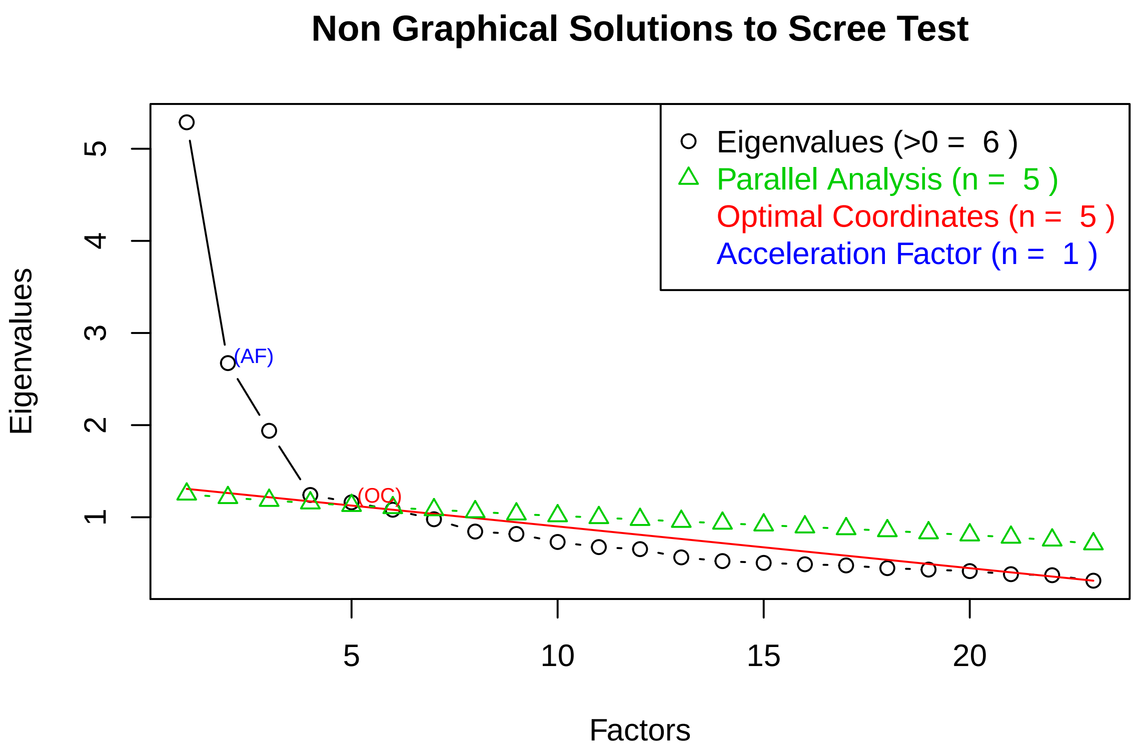

Figure 3.15: Scree Test and parallel analysis of reasons for playing games correlation matrix, EVS2.

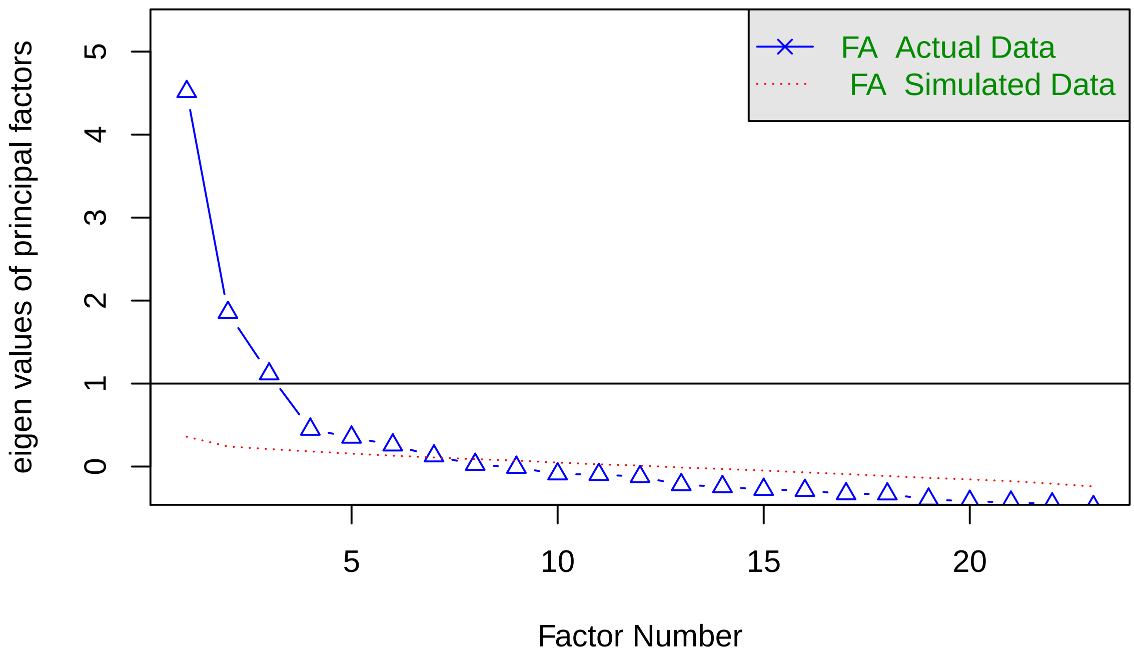

Figure 3.16: Parallel analysis of RPVG correlation matrix, EVS2.

Table 3.19: Loadings of 7-factor exploratory factor analysis of the RPVG-23.

Variable	ML1	ML3	ML2	ML4	ML5	ML6	ML7	h2	u2	com
adventure	0.03	**0.64**	-0.13	0.11	-0.01	-0.01	0.17	0.54	0.46	1.31
aggression	**0.41**	-0.03	-0.05	0.04	-0.02	0.10	**0.33**	0.36	0.64	2.13
creative	-0.05	0.00	-0.02	**0.77**	0.04	-0.03	0.00	0.57	0.43	1.02
energized	0.11	0.04	0.09	**0.46**	-0.02	-0.13	0.29	0.47	0.53	2.15
distrac1rries	**0.63**	-0.04	-0.07	0.08	0.02	0.23	0.00	0.61	0.39	1.33
playfriends	0.04	0.01	-0.08	0.03	**0.80**	-0.06	0.01	0.62	0.38	1.04
adrenaline	-0.03	0.06	0.16	0.07	0.13	0.06	**0.54**	0.51	0.49	1.39
challenge	-0.01	0.10	**0.41**	0.00	0.06	-0.12	**0.31**	0.42	0.58	2.26
onlinecommunity	-0.03	-0.07	0.29	0.03	**0.50**	0.13	0.00	0.46	0.54	1.82
reward	0.21	0.03	**0.48**	0.13	-0.04	-0.08	0.01	0.34	0.66	1.64
skill	-0.03	0.00	**0.65**	0.12	0.02	0.04	0.07	0.54	0.46	1.11
story	-0.03	**0.79**	0.08	-0.06	-0.02	-0.02	-0.04	0.59	0.41	1.05
breakfromwork	**0.54**	0.16	0.13	-0.06	0.08	-0.11	-0.01	0.32	0.68	1.47
control	0.22	0.00	0.22	0.13	-0.10	**0.44**	0.08	0.51	0.49	2.45
compete	-0.06	-0.04	**0.39**	-0.15	0.29	0.11	0.25	0.47	0.53	3.30
different	0.05	0.16	-0.01	0.02	-0.03	**0.60**	0.06	0.47	0.53	1.18
ach	0.05	0.10	**0.35**	-0.04	0.08	0.07	-0.11	0.16	0.84	1.66
stressed	**0.80**	-0.03	0.01	0.03	0.00	-0.05	0.02	0.62	0.38	1.01
inspire	0.06	0.11	0.10	**0.61**	0.03	0.13	-0.09	0.53	0.47	1.28
violence	0.04	0.05	-0.05	-0.01	0.04	0.28	**0.33**	0.22	0.78	2.11
experienceworld	0.00	**0.68**	-0.03	0.08	0.02	0.12	-0.04	0.53	0.47	1.10
ignoresurroundings	**0.51**	0.02	-0.02	-0.03	-0.02	**0.42**	-0.06	0.62	0.38	1.98
relax	**0.42**	0.20	0.08	0.03	0.06	-0.14	-0.05	0.23	0.77	1.86
SS loadings	2.35	1.76	1.63	1.51	1.18	1.23	1.07			
ML1	1.00	0.18	0.13	0.35	0.00	0.46	0.14			
ML3	0.18	1.00	0.14	0.39	-0.01	0.15	0.16			
ML2	0.13	0.14	1.00	0.24	0.37	0.11	0.39			
ML4	0.35	0.39	0.24	1.00	0.11	0.14	0.28			
ML5	0.00	-0.01	0.37	0.11	1.00	-0.04	0.29			
ML6	0.46	0.15	0.11	0.14	-0.04	1.00	0.09			
ML7	0.14	0.16	0.39	0.28	0.29	0.09	1.00			

NOTE: Factor loadings > |.3| are printed in **bold.**

Table 3.20: Correlations of Style Factors with RPVG Factors, N=961

	Immersion	Social	Achievement
StressDistract	0.37***	0.00	0.12***
Adventure	0.52***	-0.17***	0.29***
Achieve	0.21***	0.39***	0.44***
Create	0.42***	-0.03	0.18***
Social	-0.01	0.55***	0.26***
Escape	0.52***	0.00	0.09**
Excitement	0.28***	0.31***	0.39***

As shown in Table 3.20, gamers higher on the StressDistract factor tended to be higher in Immersion but not Social play style, while gamers higher on the Social RPVG factor were higher in Social play style and Achievement but not Immersion. Gamers who played for Adventure or Creativity were higher in Immersion and Achievement but not in Socialising. Scores on the Achieve and Excitement RPVG factors were correlated with all three gameplay style factors.

Higher-order factor analysis The correlations between the RPVG factors suggest a possible hierarchical factor structure. The factors relating to stress relief and escapism/distraction may be explained by one higher-order factor, while the social/achievement factors may be explained by another higher-order factor. To investigate this, I conducted an exploratory multilevel factor analysis using the `fa.multi` function in the *psych* package. The higher-order factor analysis is performed on the phi matrix, that is, the factor intercorrelation matrix. The results are presented in Table 3.21. The two higher-order factors seem to express the difference between internally and externally-focused motivations; the first factor had high loadings from the Distract and Escape factors, while the second had loadings from the Achieve, Social and Excite factors. The Adventure factor had a loading of only 0.3, and the Create factor cross-loaded onto both factors. This distinction between gaming for stress relief and gaming for fun is apparent in the network analysis of reasons for playing games, which is discussed in Chapter 6.

Table 3.21: Higher-order factor analysis of the RPVG-23

Variable	MR1	MR2	h2	u2	com
ML1	**0.74**	-0.01	0.54	0.46	1.00
ML3	**0.33**	0.14	0.15	0.85	1.35
ML2	0.05	**0.63**	0.42	0.58	1.01
ML4	**0.41**	0.29	0.30	0.70	1.80
ML6	**0.57**	-0.05	0.32	0.68	1.02
ML5	-0.19	**0.60**	0.35	0.65	1.20
ML7	0.15	**0.56**	0.37	0.63	1.14
SS loadings	1.24	1.2			
Factor correlations					
MR1	1.00	0.21			
MR2	0.21	1.00			

Steam Tags

To see whether the gameplay style factors were related to different patterns of gameplay, I used the Steam API to collect information about the titles and user-provided tags of games in participants' libraries. The 6,540 unique games played by participants of this study had only 339 unique tags, the most common of which were broad genre-related tags such as indie, action, adventure, casual, strategy, simulation, and rpg. The least common tags were related to specific content of games, such as werewolves, golf, martial arts, and sailing, and tags about the general style of a game, such as dark comedy, gothic, or psychedelic.

It is possible to visually compare actual gameplay by style factor by computing the frequency of occurrence of tags for participants with particularly high or low scores on each factor, converting the frequency matrix to an adjacency matrix and plotting as a network. The plot in Figure 3.17 show tag co-occurrence between the top 20 most played games (by number of minutes played

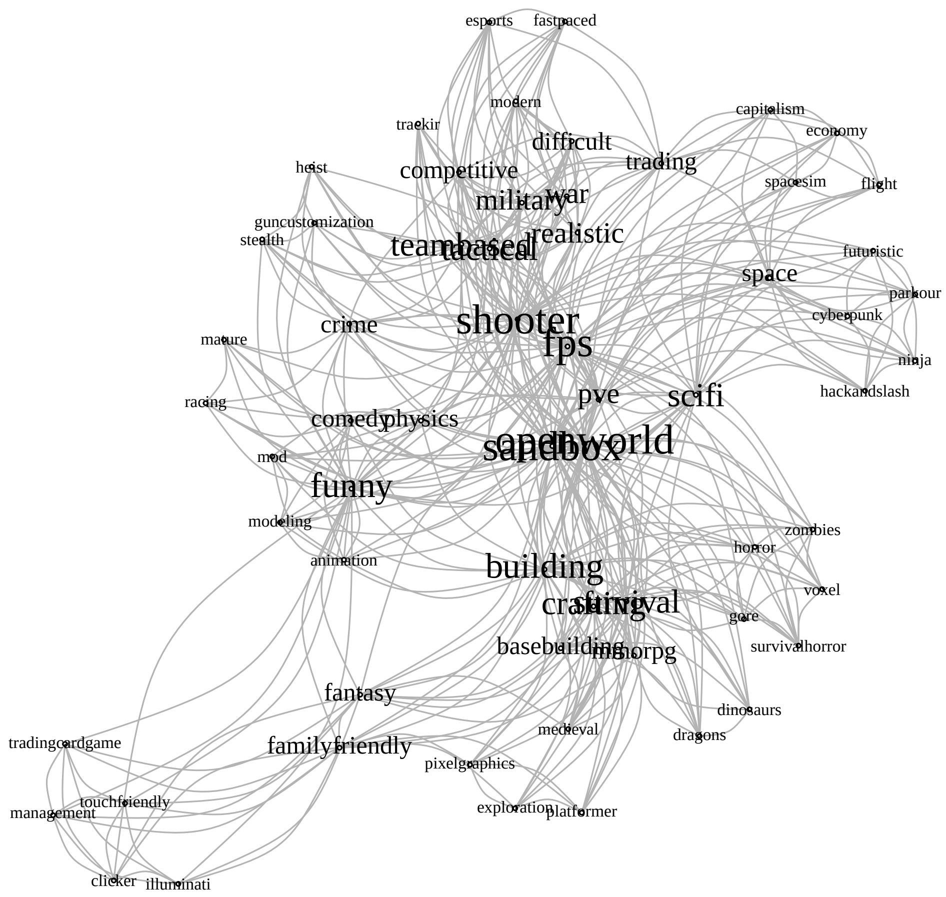

Figure 3.17: Tag co-occurrence of top 20 most played games by high-Immersion gamers, Study 3.

per participant per game) by participants with high Immersion scores (>1.5 standard deviations above the mean). Font size is scaled by number of connections through that node. A table of the titles of the games is presented in the appendix at the end of this chapter.

There were 19 participants with Immersion scores over 1.5 standard deviations above the mean. The most-played games covered several different genres, from survival horror to combat simulator to fantasy roleplaying game, but they tended to share tags of “sandbox” and “open world”.

Thirteen participants had Social factor scores over 1.5 standard deviations above the mean. As shown in Figure 3.18, fps (first person shooter), team-based, competititve and tactical were the dominant tags.

There were fewer differences between game tags for high Social and high Achievement gamers, shown in Figure 3.19.

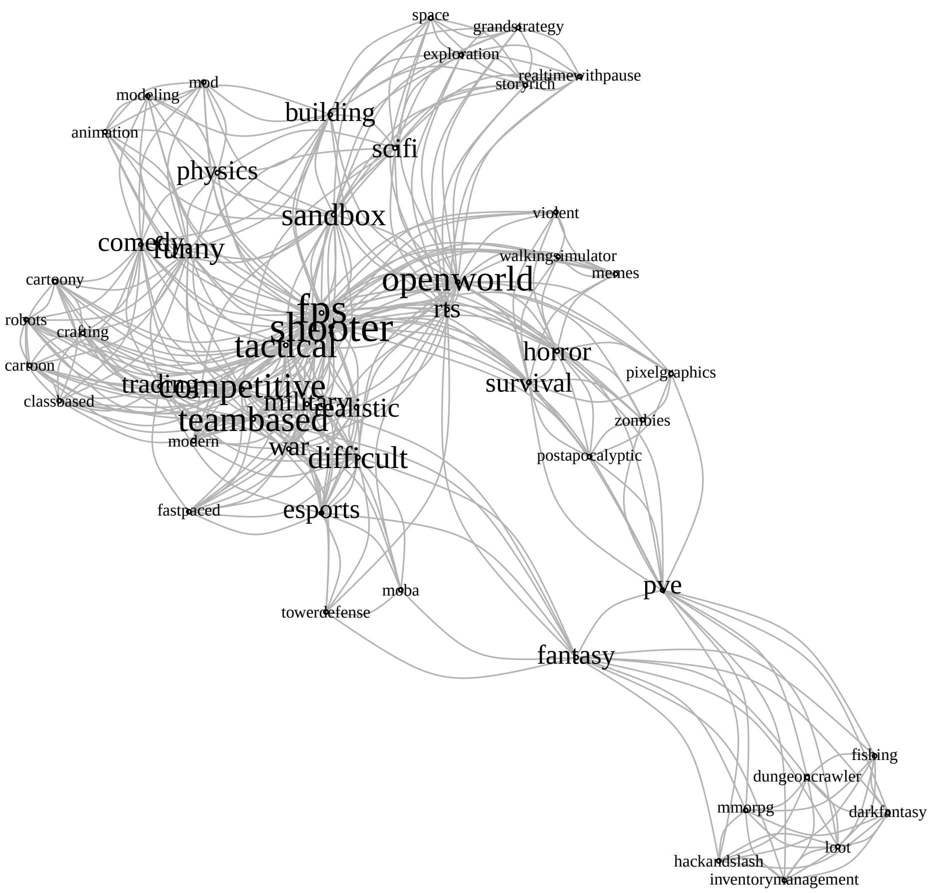

Figure 3.18: Tag co-occurrence of top 20 most played games by high-Social gamers, Study 3.

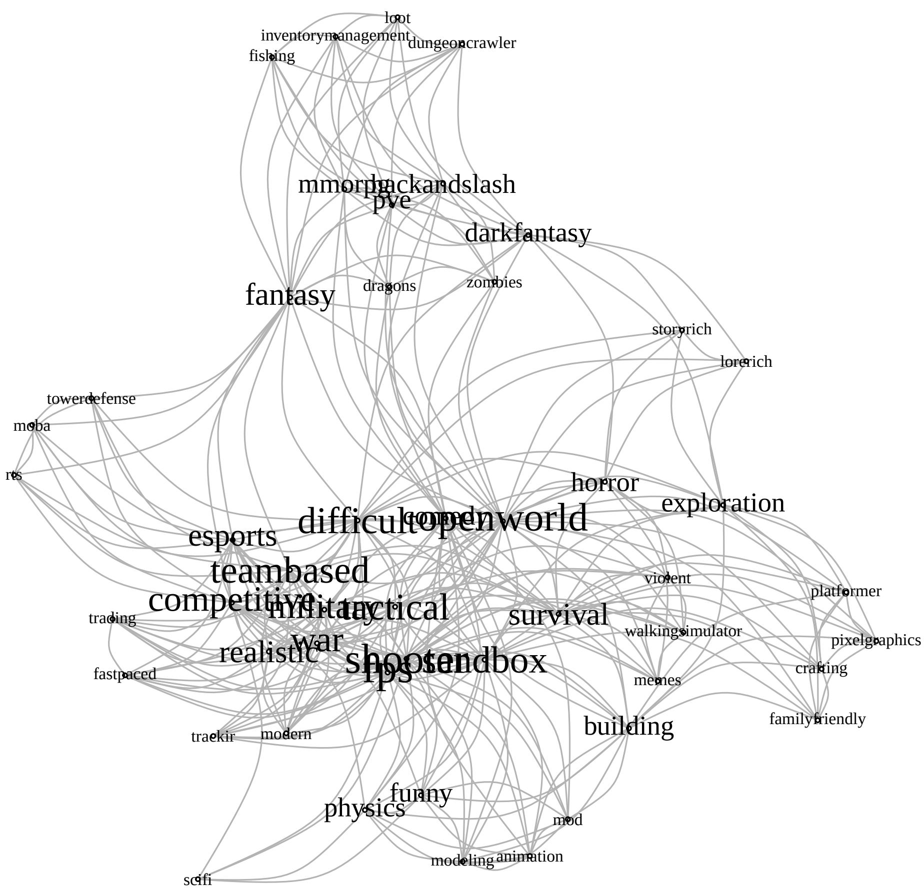

Figure 3.19: Tag co-occurrence of top 20 most played games by high-Achievement gamers, Study 3.

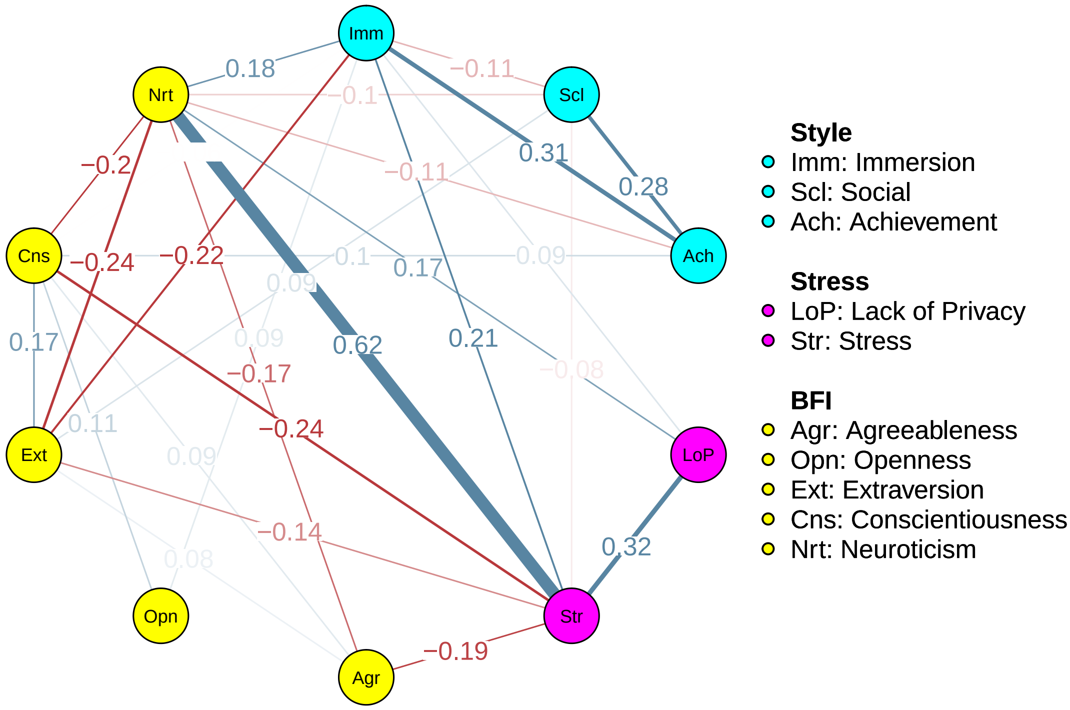

Figure 3.20: Graphical representation of correlations between gameplay style, stress, lack of privacy, and personality.

Correlations with stress, privacy, personality

Table 3.22: Correlations of Stress, Privacy, and Personality with Style Factors

	Immersion	Social	Achievement
Lack of Privacy	0.09**	-0.01	0.00
Stress	0.21***	-0.08*	-0.05
Agreeableness	-0.01	-0.01	0.01
Openness	0.09**	-0.03	0.05
Extraversion	-0.22***	0.09**	0.01
Conscientiousness	-0.06*	0.00	0.10**
Neuroticism	0.18***	-0.10**	-0.11***

As illustrated in Figure 3.20 higher scores on the Immersion factor were associated with higher stress and lack of privacy, higher openness, higher neuroticism, and lower conscientiousness and extraversion. Higher Social factor scores were associated with higher extraversion, but the correlation was very small ($r = 0.09$, $p < 0.01$). Achievement scores were slightly associated with lower neuroticism and higher conscientiousness. Given the correlations between the Immersion, Achievement and Social factors, it is noteworthy that stress score was related only to Immersion.

Comparing stress and gaming across Studies 1 and 2

A two-sample t-test on the mean perceived stress scores for Studies 1 and 2 was not statistically significant ($t(955) = -0.69$, $p = 0.49$). To formally compare the correlations between perceived stress score and the gameplay style factors across both studies, I performed Fisher's r-to-z transformation and computed Fisher's z using the `r.test` function in the *psych* package. The correlation between stress score and Immersion in Study 1 ($r = 0.16$) was not significantly different from the correlation between stress score and Immersion in Study 2 ($r = 0.21$); $z(955) = 1.01$, $p = 0.31$.

The negative correlation between stress score and Achievement observed in Study 1 ($r = -0.21$, $p < 0.001$) was not replicated in Study 2 ($r = -0.05$, $p = 0.1$). Fisher's z indicates that the two correlations are significantly different, $z(955) = 2.91$, $p < 0.001$. No significant correlation between stress score and the Social gameplay style factor in either study.

Summary

Study 2 was a replication and expansion of Study 1, examining correlations between gameplay style, motivations, genre preference, personality, and perceived stress in a sample of 981 adult and adolescent gamers. Consistent with Study 1, it found only small correlations of the Big Five personality traits with genre preference, with more extraverted gamers more likely to prefer sports and less likely to prefer puzzle games, more agreeable gamers preferring adventure without combat, and gamers more open to experiences preferring exploration and puzzle games.

The three-factor Immersion-Social-Achievement structure of gameplay observed in Study 1 was replicated in Study 2. Higher scores on the Immersion factor were associated with a preference for roleplaying, exploration, sandbox and adventure games. Higher scores on the Social factor were associated with a preference for massively multiplayer and shooter games, and higher scores on the Achievement factor were associated with preference for combat and strategy games. Immersion-oriented gamers were higher in neuroticism, lower in extraversion, and higher in perceived stress. Social gamers were slightly lower in stress and Neuroticism and higher in Extraversion (though this correlation was small, $r = 0.09$), and Achievement-oriented gamers were higher in Conscientiousness and lower in Neuroticism.

This study introduced a new set of items measuring reasons for playing games developed from an open-response questionnaire and indicating seven factors: Distract, Adventure, Achieve, Create, Social, Escape, and Excite. The Distract and Escape factors were correlated with perceived stress, ($r = 0.45$ and $r = 0.42$, respectively) while the Social factor was slightly negatively correlated with perceived stress ($r = -0.14$).

Gamers experiencing more stress appear to prefer Immersion rather than Social or Achievement play styles and are more likely to play explicitly for distraction or escape.

Appendix: EVS2 Study

Table 3.23: Descriptive statistics of the genre preference variables.

Statistic	N	Mean	St. Dev.	Min	Max
adventurecombat	961	3.93	0.88	1	5
shooter	961	3.67	1.07	1	5
simulation	961	2.55	1.17	1	5
casual	961	1.78	0.94	1	5
adventurenocombat	961	2.41	1.00	1	5
sports	961	1.69	1.05	1	5
grandstrategy	961	2.76	1.23	1	5
massivelymultiplayer	961	2.92	1.38	1	5
exploration	961	2.49	1.15	1	5
puzzle	961	2.37	0.99	1	5
roleplaying	961	4.00	0.95	1	5
sandbox	961	3.36	1.08	1	5
racing	961	1.95	0.99	1	5

Table 3.24: Descriptive statistics of the gameplay style variables.

Statistic	N	Mean	St. Dev.	Min	Max
randomStrangers	961	3.40	1.19	1	5
tryBeat	961	3.88	0.90	1	5
feelSomewhereElse	961	3.71	1.02	1	5
dontGiveUp	961	3.73	0.97	1	5
preferComputer	961	3.06	1.18	1	5
scoresAch	961	2.86	1.16	1	5
emotionsStay	961	3.37	1.01	1	5
logicStrategy	961	3.91	0.94	1	5
charactersFeelReal	961	2.93	1.12	1	5
moreComfortableInGame	961	2.85	1.27	1	5
gamePhysicalSpace	961	2.67	1.24	1	5

Table 3.25: Descriptive statistics of the reasons for playing games variables.

Statistic	N	Mean	St. Dev.	Min	Max
adventure	961	3.99	0.89	1	5
aggression	961	2.49	1.19	1	5
creative	961	3.15	1.09	1	5
energized	961	3.00	1.14	1	5
distrac1rries	961	3.54	1.24	1	5
playfriends	961	3.42	1.19	1	5
adrenaline	961	2.82	1.19	1	5
challenge	961	3.71	0.99	1	5
onlinecommunity	961	2.66	1.23	1	5
reward	961	2.61	1.25	1	5
skill	961	2.84	1.23	1	5
story	961	4.10	0.93	1	5
breakfromwork	961	3.98	1.09	1	5
control	961	2.91	1.28	1	5
compete	961	2.94	1.30	1	5
different	961	2.86	1.40	1	5
ach	961	2.35	1.23	1	5
stressed	961	3.24	1.15	1	5
inspire	961	2.79	1.18	1	5
violence	961	2.30	1.18	1	5
experienceworld	961	4.16	0.89	1	5
ignoresurroundings	961	3.02	1.31	1	5
relax	961	4.23	0.86	1	5

	rStr	tryBt	flSomeElse	dntGiveUp	prfComp	scrAch	emStay	logStr	chFlRl	mComInGame
randomStrangers										
tryBeat	0.17***									
feelSomewhereElse	0.02	0.20***								
dontGiveUp	0.16***	0.48***	0.18***							
preferComputer	-0.48***	-0.06	0.15***	-0.07*						
scoresAch	0.21***	0.33***	-0.01	0.19***	-0.16***					
emotionsStay	0.06	0.20***	0.28***	0.15***	0.02	0.12***				
logicStrategy	0.08*	0.29***	0.08**	0.22***	-0.03	0.22***	0.16***			
charactersFeelReal	-0.05	0.13***	0.41***	0.14***	0.17***	0.05	0.40***	0.13***		
moreComfortableInGame	0.09**	0.08*	0.41***	0.07*	0.11***	0.10**	0.27***	0.06*	0.36***	
gamePhysicalSpace	0.00	0.10**	0.37***	0.08*	0.13***	0.11***	0.32***	0.12***	0.54***	0.41***

Table 3.26: Correlation matrix of gameplay style variables. *** $p < .001$, ** $p < .01$, *$p < .05$

Table 3.27: Titles of Steam games played by participants with scores greater than 1.5 standard deviations above the mean in each of the three gameplay style factors.

Immersion	Social	Achievement
X3: Terran Conflict	Team Fortress 2	Counter-Strike: Global Offensive
7 Days to Die	Path of Exile	Neverwinter
ARK: Survival Evolved	PLAYERUNKNOWN'S BATTLEGROUNDS	Tiger Knight: Empire War
Wurm Unlimited	Half-Life 2: Deathmatch	Path of Exile
Grand Theft Auto V	Counter-Strike: Global Offensive	DARK SOULS III
Half-Life 2: Deathmatch	Source SDK	PLAYERUNKNOWN'S BATTLEGROUNDS
Garry's Mod	Garry's Mod	Half Life 2: Deathmatch
Terraria	Dota 2	Garry's Mod
Counter-Strike: Global Offensive	Arma 2: Operation Arrowhead	Terraria
Source SDK	Infestation: Survivor Stories	Source SDK
Call of Duty: Modern Warfare 2	Rocket League	Counter-Strike: Source
Arma 2: Operation Arrowhead	Stellaris	Rocket League
Arma 3		Arma 2: Operation Arrowhead
The Elder Scrolls V: Skyrim		Arma 3
Warframe		Dota 2
PAYDAY 2		
RPG Maker MV		
Clicker Heroes		

CHAPTER 4

EXTENDING GAMEPLAY STYLE: MINECRAFT AND AUTISM

Minecraft is a unique phenomenon. With over 100 million copies sold since its release only nine years ago, it is already the best-selling PC game of all time and on track to pass Tetris as the best-selling game on any platform. Created by independent developer Mojang, Minecraft was sold in 2014 to Microsoft for $2.5 billion, and its popularity continues to rise (http://www.theguardian.com/technology/2014/sep/15/microsoft-buys-minecraft-creator-mojang-for-25bn). It is available to play on a large number of platforms and devices, with mobile as well as console and desktop versions.

The game has much in common with LEGO, in that the game world is made up of voxel-based blocks one cubic meter in dimension in comparison with the player character; see Figure 4.1 for a screenshot of players in Minecraft. The game world is procedurally generated and theoretically unlimited in size and depending on game mode can include various biomes such as desert, taiga, ocean, mountains, jungle, and open plains. There are two fundamental modes available to the player: a "creative" mode in which the player can fly and can create and destroy any of the approximately 150 types of block, though the blocks can generally only be created or destroyed one at a time, and a "survival" mode, in which the player must gather resources and build shelters in order to fend off starvation and aggressive monsters known as "mobs."

Many gamers play online on servers, which may be public or private; the largest servers can support

Figure 4.1: Screenshot of several players in Minecraft, from https://education.minecraft.net/press/.

several thousand players sharing the same virtual world simultaneously, sometimes developing elaborate communities or building extremely large and sophisticated models. Minecraft has an electronics mechanic based on a conductive material known as "redstone," and players have begun to create working hard drives and even fully functional computers within the game.

Study 3

Mazurek, Engelhardt, & Clark (2015)'s interview study of 58 adults with autism spectrum conditions found that common motivations included stress relief, immersion, time use, and social connection. Positive aspects of gaming included enjoying achievement, creativity, story, and game graphics, while negative aspects included addiction and negative social interactions, and many participants disliked game violence, sexual content, and game design problems.

In collaboration with the Cambridge Autism Research Centre, I administered a version of the questionnaires in Study 1 to a sample of adults and children with an ASC. The study was a mixed-methods investigation of gameplay style in general and Minecraft use in particular, in response to observations that Minecraft is particularly appealing to children with an ASC (Marzurek & Wenstrup, 2013). The study also investigated perceptions of the positive and negative effects of gaming among 62 autistic adults and 44 parent-child dyads. As this dissertation focuses on the quantitative factor and network structures of gaming motivation and style, only the relevant portions of Study 3 will be described here.

Methods

Procedure

The study was an online questionnaire advertised via emails to registered participants of the Cambridge Autism Research Database. It consisted of most of the items and measures used in Study 1, including both open-response and forced-choice items about gameplay time, genre preferences, reasons for playing, and gameplay style. New items included open-response questions for both child and parent regarding reasons for playing games, the effect of games in general and Minecraft in particular on the parent/child relationship, and perceived positive and negative effects on the child's wellbeing; as mentioned in the previous paragraph, this portion of the study is beyond the scope of this dissertation.

As in the previous study, I collected Steam API data on the specific games owned, the amount of time spent playing each game, and achievements from those participants who use Steam and choose to provide their user IDs.

Depending upon the age of the participant, participants were given either the adult, adolescent, or child versions of the survey. The adult and adolescent versions differ only in instructions to the participant and consent forms, while the child version is modified for parent-report with input from the child. The Perceived Stress Scale (PSS-10, Cohen et al. (1983)) was administered to adult participants only.

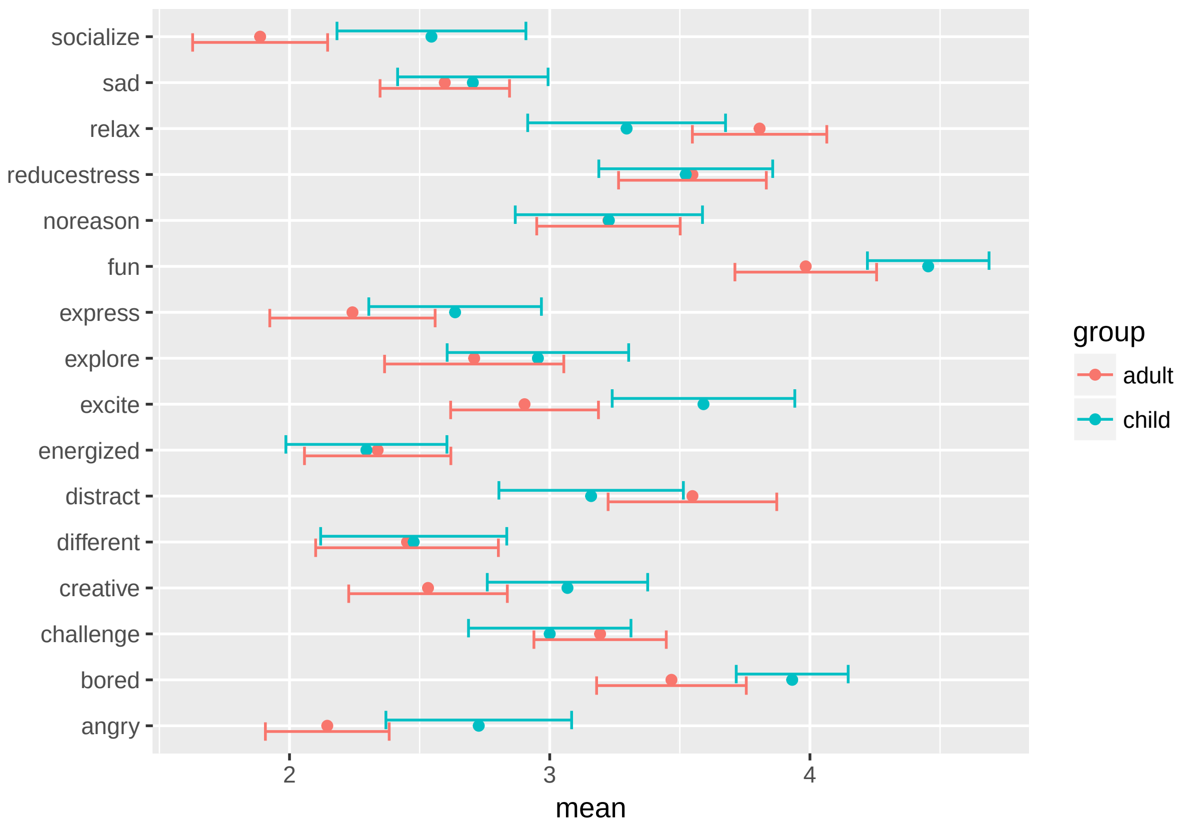

Figure 4.2: Means of Reasons for Playing Video Games items.

Stress and privacy

Perceived stress score for the 68 participants who completed the PSS-10 was high, with mean = 22.37 (SD = 7.44) (alpha = 0.89); this is consistent with research that ASC individuals experience more stress in their daily lives than their neurotypical counterparts (Gillott & Standen, 2007) and generally have higher scores on the Perceived Stress Scale (Hirvikoski & Blomqvist, 2015). The ASC sample was also lower in privacy and personal space than the sample in Study 1, with a mean = 11.4 (SD = 5.82), Cronbach's alpha = 0.86. Despite the small sample size, there was a marginally significant correlation between perceived stress score and playing to reduce stress: r = 0.23 (p = 0.054, 95% CI -0.004 - 0.448).

Gaming motivation

As shown in Figure 4.2, there were several differences in gaming motivation between the adults and children. Neither group tended to play to socialise, though adults were significantly less likely than children. Adults were also less likely to play for excitement.

Results

Factor analysis of gameplay style

As with Study 1, I conducted a maximum likelihood estimation factor analysis with oblimin rotation and specified a 3-factor solution. The fit of the model was good, with a Tucker Lewis Index = 0.957 and RMSEA index = 0.055. The three factors were clearly consistent with Study 1, with factor congruence coefficients of 0.91, 0.93, and 0.92 for Immersion, Achievement, and Social.

Table 4.1: Loadings of the exploratory factor analysis of gameplay style among adults and children with an autism spectrum condition. N=106

Variable	ML1	ML3	ML2	h2	u2	com
randomStrangers	-0.04	0.02	**0.84**	0.69	0.31	1.01
onlineTeam	0.10	0.05	**0.78**	0.68	0.32	1.04
tryBeat	0.00	**0.79**	0.04	0.64	0.36	1.01
feelSomewhereElse	**0.54**	0.11	0.06	0.38	0.62	1.11
dontGiveUp	-0.01	**0.78**	-0.04	0.59	0.41	1.00
preferComputer	0.13	0.28	**-0.46**	0.25	0.75	1.86
scoresAch	0.18	**0.47**	-0.07	0.31	0.69	1.35
emotionsStay	**0.50**	0.18	0.07	0.38	0.62	1.30
logicStrategy	-0.04	**0.68**	0.06	0.46	0.54	1.02
charactersFeelReal	**0.73**	0.04	0.04	0.57	0.43	1.01
moreComfortableInGame	**0.92**	-0.07	-0.03	0.80	0.20	1.01
gamePhysicalSpace	**0.34**	0.02	**0.35**	0.30	0.70	2.01
SS loadings	2.23	2.14	1.7			
ML1	1.00	0.39	0.27			
ML3	0.39	1.00	0.21			
ML2	0.27	0.21	1.00			

Correlations with Reasons for Playing Games

Table 4.2: Correlations of Style Factors with Reasons for Playing Games Variables

	Immersion	Social	Achievement
relax	0.19	-0.06	0.29**
energized	0.42***	0.20*	0.26**
reducestress	0.34***	-0.03	0.35***
distract	0.49***	0.10	0.38***
fun	0.22*	0.03	0.25**
socialize	0.34***	0.48***	0.20*
challenge	0.20*	0.24*	0.52***
excite	0.43***	0.15	0.33***
angry	0.24*	0.12	0.23*
bored	0.32***	0.21*	0.27**
sad	0.35***	0.10	0.36***
noreason	0.26**	0.33***	0.24*
creative	0.38***	0.25*	0.11
express	0.41***	0.27**	0.14
different	0.62***	0.35***	0.39***
explore	0.60***	0.36***	0.38***

As shown in Table 4.2 and graphically in Figure 4.3, Immersion and Achievement were significantly correlated with r = 0.46, in contrast to Study 1, and playing to reduce stress, distract from worries, or when sad or angry was correlated with both the Achievement and Immersion factors. However, autistic gamers who played to relax tended to have an Achievement rather than Immersion

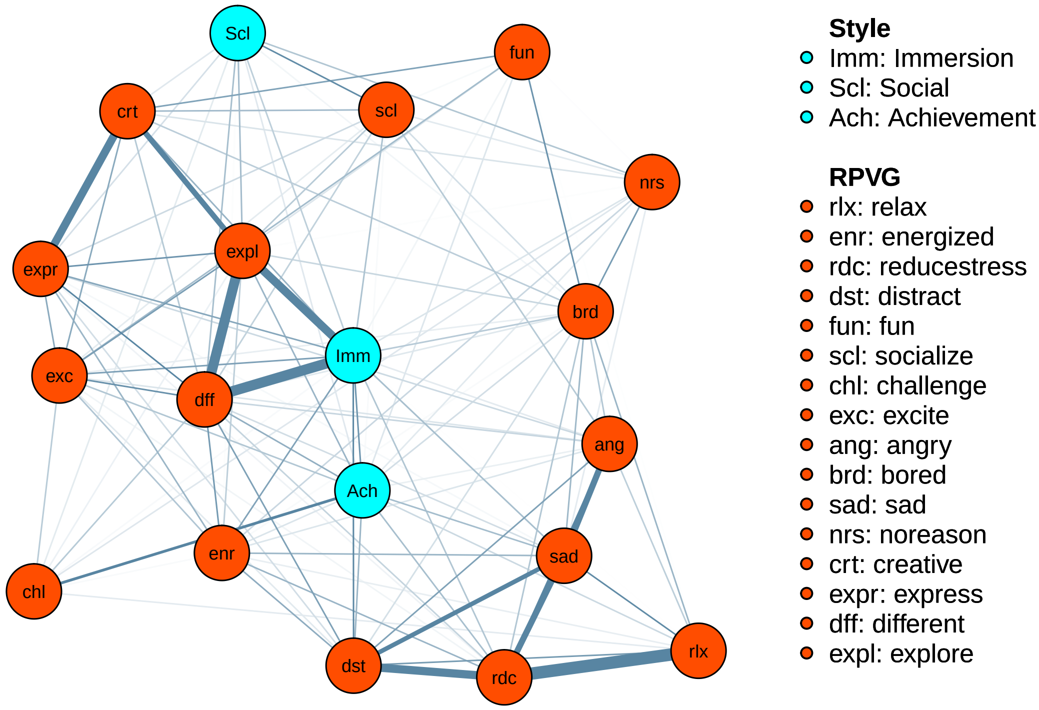

Figure 4.3: Correlations of Gameplay Style with Reasons for Playing Games. N=107

or Social play style. A Social play style was not associated with any of the emotion or stress management reasons for playing games.

Correlations with stress, privacy, gameplay frequency

Table 4.3: Correlations of Stress, Privacy, Gameplay Frequency with Style Factors

	Immersion	Social	Achievement
Lack of Privacy	0.23	0.27*	0.17
Stress	0.35**	0.09	0.24
Days Played	0.32***	0.20*	0.32**
Hours Played	0.35***	0.24*	0.31**

Perceived stress score was correlated with Immersion ($r = 0.35$, $p < 0.01$, Table 4.3), but the correlation between stress and Achievement was estimated to be $r = 0.24$ with $p = 0.054$ and a wide 95% confidence interval of -.004 to 0.454. This is likely due to the small sample size.

Comparison with neurotypical sample

To compare the correlation of stress and gameplay style in the sample of autistic gamers with the neurotypical sample in EVS1, I performed Fisher's r-to-z transformation and computed Fisher's z. There was no significant difference between the correlation of stress score with Immersion in the neurotypical sample ($r = 0.16$, $p < 0.001$) and the autistic sample ($r = 0.35$, $p < 0.01$); $z(478) = 1.47$, $p = 0.14$.

As noted in Chapter 3, the negative correlation between stress and Achievement observed in the EVS1 study did not replicate in EVS2. These two variables had a positive relationship in the sample of autistic gamers, with $r = 0.24$ ($p = 0.05$), and this correlation was significantly different from both the EVS1 ($z(478) = 3.32$, $p = 0.00$) and EVS2 studies ($z(958) = 2.21$, $p = 0.03$).

Summary

Study 3 replicated the three-factor structure of gameplay style in a sample of 106 adults and children with an Autism Spectrum Condition. In contrast to Study 1, the Immersion and Achievement factors were correlated with each other and both were associated with playing to relieve stress, distract from worries, and escape from real life, though only Immersion was related to playing for relaxation. Autistic gamers may feel more engaged by the logic and strategy that characterises an Achievement play style.

Appendix: MA

Table 4.4: Descriptive statistics of gameplay style among autistic adults and children.

Statistic	N	Mean	St. Dev.	Min	Max
randomStrangers	103	2.09	1.29	1	5
onlineTeam	103	1.70	1.13	1	5
tryBeat	103	3.55	1.18	1	5
feelSomewhereElse	103	2.84	1.28	1	5
dontGiveUp	103	3.29	1.06	1	5
preferComputer	103	3.60	1.22	1	5
scoresAch	103	3.20	1.36	1	5
emotionsStay	103	3.14	1.16	1	5
logicStrategy	103	3.72	1.12	1	5
charactersFeelReal	103	2.60	1.33	1	5
moreComfortableInGame	103	3.03	1.33	1	5
gamePhysicalSpace	103	1.95	1.21	1	5

Table 4.5: Descriptive statistics of reasons for playing games among autistic adults and children.

Statistic	N	Mean	St. Dev.	Min	Max
relax	106	3.59	1.17	1	5
energized	106	2.32	1.09	1	5
reducestress	106	3.54	1.13	1	5
distract	106	3.39	1.27	1	5
fun	106	4.18	1.00	1	5
socialize	106	2.16	1.16	1	5
challenge	106	3.11	1.04	1	5
excite	106	3.19	1.20	1	5
angry	106	2.39	1.10	1	5
bored	106	3.66	1.02	1	5
sad	106	2.64	0.99	1	5
noreason	106	3.23	1.15	1	5
creative	106	2.75	1.18	1	5
express	106	2.41	1.22	1	5
different	106	2.46	1.33	1	5
explore	106	2.81	1.30	1	5

Table 4.6: Correlation matrix of gameplay style variables, Study 3. *** $p < .001$, ** $p < .01$, *$p < .05$

	rStr	onlTeam	tryBt	flSomeElse	dntGiveUp	prfComp	scrAch	emStay	logStr	chFlRl	mComInGame
randomStrangers											
onlineTeam	0.67***										
tryBeat	0.16	0.24*									
feelSomewhereElse	0.17	0.21*	0.26**								
dontGiveUp	0.13	0.12	0.62***	0.29**							
preferComputer	-0.33***	-0.26**	0.17	0.08	0.17						
scoresAch	0.08	0.12	0.44***	0.09	0.39***	0.20*					
emotionsStay	0.18	0.27**	0.36***	0.45***	0.29**	0.04	0.26**				
logicStrategy	0.12	0.24*	0.52***	0.26**	0.52***	0.18	0.38***	0.19			
charactersFeelReal	0.19	0.27**	0.25**	0.47***	0.24*	0.02	0.34***	0.50***	0.24*		
moreComfortableInGame	0.13	0.27**	0.25*	0.51***	0.22*	0.13	0.31**	0.49***	0.15	0.67***	
gamePhysicalSpace	0.36***	0.41***	0.19	0.43***	0.13	0.01	0.11	0.24*	0.23*	0.21*	0.41***

Table 4.7: Correlation matrix of gaming motivations variables, Study 3. *p < .05

	rlx	enrg	rdstress	dst	fun	soc	ch	exc	ang	brd	sad	nrs	crea	exp	diff
relax															
energized	0.24*														
reducestress	0.65*	0.39*													
distract	0.44*	0.39*	0.57*												
fun	0.19*	0.09	0.11	-0.01											
socialize	0.08	0.18	0.14	0.05	0.20*										
challenge	0.24*	0.21*	0.15	0.17	0.02	0.11									
excite	0.05	0.32*	0.21*	0.24*	0.36*	0.22*	0.32*								
angry	0.32*	0.27*	0.50*	0.42*	0.15	0.34*	0.03	0.25*							
bored	0.35*	0.20*	0.35*	0.23*	0.44*	0.25*	0.14	0.25*	0.32*						
sad	0.48*	0.37*	0.57*	0.52*	0.08	0.15	0.12	0.17	0.56*	0.40*					
noreason	0.13	0.30*	0.11	0.04	0.20*	0.25*	0.26*	0.09	-0.01	0.44*	0.25*				
creative	0.01	0.20*	0.07	0.00	0.42*	0.38*	0.11	0.38*	0.20*	0.29*	0.11	0.27*			
express	0.01	0.39*	0.23*	0.26*	0.15	0.30*	0.13	0.39*	0.30*	0.16	0.20*	0.10	0.60*		
different	0.15	0.44*	0.31*	0.41*	0.17	0.30*	0.33*	0.48*	0.29*	0.29*	0.30*	0.13	0.31*	0.49*	
explore	0.18	0.31*	0.19*	0.17	0.25*	0.32*	0.23*	0.44*	0.18	0.34*	0.25*	0.21*	0.53*	0.45*	0.63*

Study 4

This study explores the Minecraft sections of the previous three studies, investigating how the gameplay style factors are related to play style in Minecraft.

Methods

Participants

The participants were those who completed the Minecraft sections of Studies 1, 2 and 3. These had sample sizes of 138 in Study 1, 380 in Study 2, and 50 in Study 3. In general, Minecrafters were younger than non-Minecrafters, but there were no significant differences in education, employment, or living situation within their respective samples.

Procedure

After completing the main portion of the questionnaires in Studies 1, 2 and 3, participants completed an additional set of items related to their experience and style preferences in Minecraft. They were asked to indicate how long they had played Minecraft, how much time they generally spent playing, and how often they played in the various game modes Minecraft offers. Socialising in Minecraft was indicated by how often participants reported playing on shared servers versus in single player mode, whether they played with friends they knew in real life, friends they did not know outside the game but played regularly with, and strangers they happened to interact with on servers.

Minecraft style

Play style and experiences within the game were measured by 13 items in which participants were asked to indicate "how often the following statements accurately describe your Minecraft experience" on a five-point scale from never to always. Some items were related to flow and presence: "I feel like I'm really in the game world", "I lose track of time". Others measured systematic versus exploratory play: "I build specific models based on real life", "I build redstone circuits", "I prefer spelunking rather than methodical mining", "I am careful not to get lost". Finally, some items were related to the feeling of "cosiness": base building is a common feature in survival games, and it is possible that building a cosy, safe virtual base provides comfort to the player. These items included "I try to make my houses and bases feel cosy", and "I feel nervous when my character is not safe".

General differences between means are highlighted in Figure 4.4. ASC Minecrafters (the Study 3 group) tended to be higher on the immersion variables, especially "I tend to lose track of time". They also tended to prefer a more systematic gameplay style: they were less likely to prefer exploring caves rather than methodical mining and were more careful not to get lost than their neurotypical counterparts.

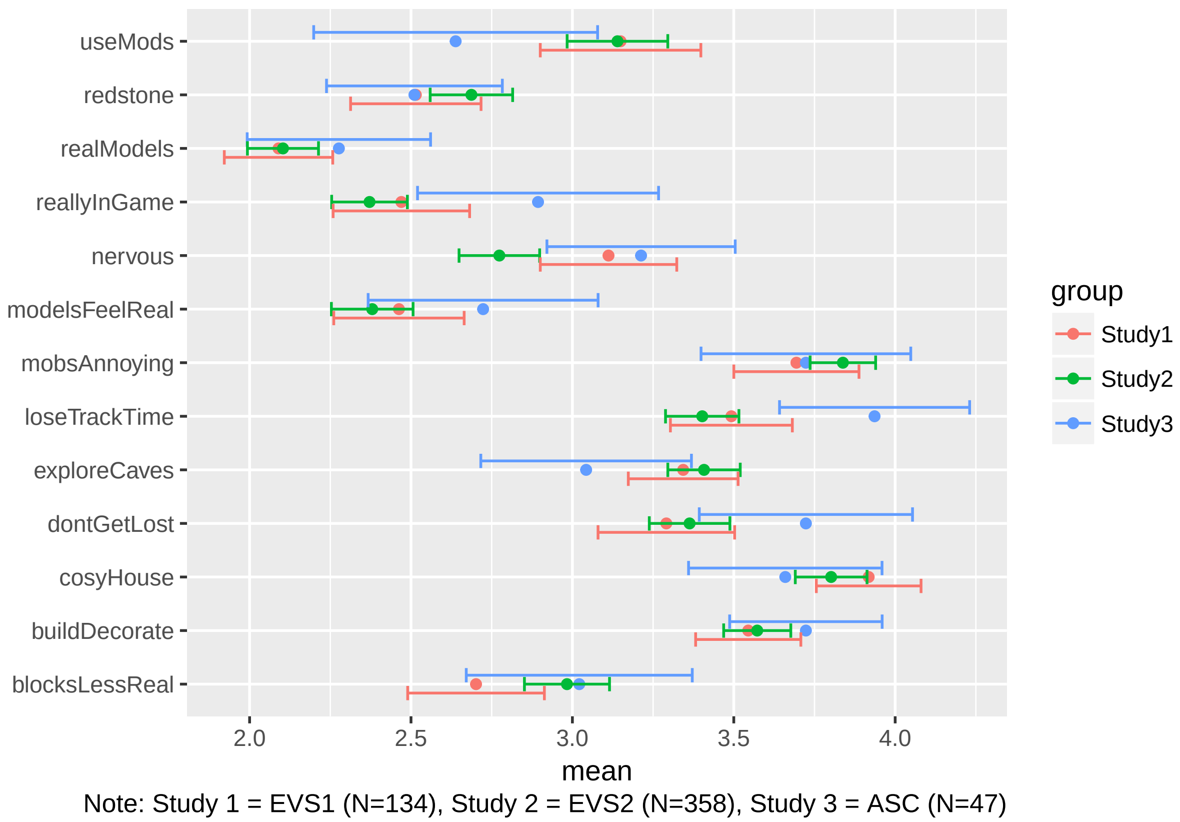

Figure 4.4: Comparison of means of Minecraft Style variables across Studies 1, 2, and 3.

Results

Correlations of Minecraft Style and General Style Factors

Study 1 Correlations between the Minecraft style items and the general gaming style factors are shown in Figure 4.8. As expected, the immersion-related Minecraft items were strongly correlated with the general Immersion factor. The presence Minecraft items ("I feel like I'm really in the game world" and "The models feel like real places") correlated most strongly with Immersion, with r = 0.57 and r = 0.54, respectively. Dissociation ("I lose track of time") and engagement ("I feel nervous when my character is not safe") also correlated with general Immersion, with r = 0.30 and 0.41, respectively. Interestingly, "cosiness" of houses and bases was correlated more strongly with the Social style factor ($r = 0.30$, $p < 0.001$) than with Immersion ($r = 0.17$, $p < 0.05$).

Study 2 The same general pattern of correlations appeared in Study 2 (Figure 4.9). Due to the larger sample size, several new correlations were detected. Using redstone circuits (the in-game electronics mechanic) slightly correlated with Immersion and Achievement ($r = 0.18$, $p < 0.001$ for both), and preferring exploring caves over methodical mining was slightly correlated with the Immersion and Social factors but uncorrelated with Achievement, as we would expect.

Study 3 For gamers with an Autism Spectrum Condition, most of the immersion-related Minecraft style variables were correlated with the general Immersion factor, but there were a few

Table 4.8: Minecraft Style Variable Correlations with Style Factors, Study 1. N = 138

	Immersion	Social	Achievement
Building, decorating	0.08	-0.10	0.12
Models based on real life	0.13	0.06	-0.04
Redstone circuits	0.22*	-0.03	0.23**
Exploring caves	0.07	0.00	0.05
Careful not to get lost	-0.13	-0.05	0.11
Mods and resource packs	0.15	0.07	0.00
Houses and bases feel cozy	0.17*	0.31***	0.02
Blocky textures feel less real	-0.23**	0.04	0.06
Really in the game world	0.57***	-0.06	-0.04
I lose track of time	0.32***	0.00	-0.08
Mobs are more annoying than scary	0.10	0.13	0.22*
Nervous when character not safe	0.42***	-0.10	-0.03
Models feel like real places	0.54***	-0.10	0.00

Table 4.9: Minecraft Style Variable Correlations with Style Factors, Study 2. N = 380

	Immersion	Social	Achievement
Building, decorating	0.08	0.37***	0.19***
Models based on real life	0.14**	-0.17**	-0.01
Redstone circuits	0.18***	0.00	0.18***
Exploring caves	0.12*	0.04	0.10
Careful not to get lost	0.11*	0.13*	0.05
Mods and resource packs	0.06	-0.02	-0.07
Houses and bases feel cozy	0.03	0.18***	0.10
Blocky textures feel less real	0.20***	0.01	0.09
Really in the game world	-0.13*	0.14**	0.14*
I lose track of time	0.43***	-0.19***	0.00
Mobs are more annoying than scary	0.25***	-0.02	0.07
Nervous when character not safe	0.14**	0.18***	0.14**
Models feel like real places	0.14**	-0.10	0.01

key differences. As shown in Table 4.10, building and decorating and creating models based on real life were strongly associated with a social gaming style; these variables were uncorrelated in the neurotypical sample of Study 1. Making houses and bases feel cosy was negatively correlated with the Social factor among ASC gamers ($r = -0.45$, $p < 0.001$), but positively correlated in the neurotypical samples of Studies 1 and 2.

The use of redstone circuits was very strongly correlated with Achievement ($r = 0.87$, $p < 0.001$) among autistic gamers, as was the use of mods and resource packs ($r = 0.80$, $p < 0.001$). Interestingly, autistic gamers high in Achievement were more likely to feel like they are really in the game world (though this item was also correlated with Immersion to a lesser extent), and more likely to feel nervous when their character is not safe ($r = 0.81$, $p < 0.001$). Autistic gamers may be more emotionally engaged by an Achievement play style and feel nervous when their character is not safe because of the risk of losing progress in the game if the character dies.

Minecraft play style and perceived stress

Perceived stress score had small but significant correlations with several of the Minecraft style variables, though only "I feel nervous when my character is not safe" was significant in both Study 1 and Study 2 (Figure 4.11. Only 22 participants in Study 3 completed both the perceived stress scale and the Minecraft style questionnaire, so Study 3 is not included in this analysis. Building and decorating and making houses and bases feel cosy was positively correlated with stress in Study 2 but not in Study 1. The immersion-related items of "I feel like I'm really in the game world", "I lose track of time" and "The models feel like real places" were correlated with

Table 4.10: Minecraft Style Correlations with Style Factors, Study 3. N = 50

	Immersion	Social	Achievement
Building, decorating	-0.16	0.87***	0.09
Models based on real life	0.10	0.88***	0.28*
Redstone circuits	0.22	0.27	0.87***
Exploring caves	0.54***	-0.13	0.32*
Careful not to get lost	0.15	-0.09	0.14
Mods and resource packs	0.16	0.07	0.80***
Houses and bases feel cozy	0.14	-0.45**	0.12
Blocky textures feel less real	-0.04	0.43**	0.22
Really in the game world	0.30*	-0.03	0.47***
I lose track of time	-0.19	-0.02	0.11
Mobs are more annoying than scary	0.42**	0.02	0.27
Nervous when character not safe	0.26	0.23	0.81***
Models feel like real places	0.78***	-0.01	0.30*

stress in Study 1 but not in Study 2.

Table 4.11: Comparison of correlations of perceived stress score with Minecraft style in Study 1 (N=138) and Study 2 (N=380).

	Stress, Study 1	Stress, Study 2
Building, decorating	-0.08	-0.11*
Models based on real life	0.15	0.17**
Redstone circuits	0.03	0.03
Exploring caves	-0.12	-0.11*
Careful not to get lost	-0.07	0.06
Mods and resource packs	0.04	0.06
Houses and bases feel cozy	0.07	-0.05
Blocky textures feel less real	-0.07	0.16**
Really in the game world	0.22**	0.04
I lose track of time	0.34***	0.09
Mobs are more annoying than scary	0.08	0.09
Nervous when character not safe	0.30***	-0.03
Models feel like real places	0.21*	0.18***

Summary

Study 4 investigated the correlations between the three gameplay style factors and a set of 13 items relating to Minecraft play style across three independent datasets. In the two neurotypical samples, Immersion was associated with models feeling like real places, feeling physically present in the game world, making houses and bases feel cosy and feeling nervous when their character was not safe. For the autistic gamers, Immersion was also associated with a sense of physical presence in the game world but was not associated with feeling nervous when their character was not safe; instead, this was highly correlated with the Achievement factor.

The small sample size prevented a correlation analysis of perceived stress and Minecraft style in the sample of autistic gamers, but in the two neurotypical samples perceived stress was correlated with feeling nervous when their character was not safe. Building, decorating, and making houses and bases feel cosy was correlated with perceived stress in Study 2 but not in Study 1, and as the magnitudes of these correlations were small (< 0.2) it is possible that they were not detected in Study 1 due to its smaller sample size.

Appendix: Study 4

Table 4.12: Minecraft play style descriptive statistics, EVS1.

Statistic	N	Mean	St. Dev.	Min	Max
buildDecorate	134	3.54	0.96	1	5
realModels	134	2.09	0.99	1	5
redstone	134	2.51	1.19	1	5
exploreCaves	134	3.34	1.00	1	5
dontGetLost	134	3.29	1.25	1	5
useMods	134	3.15	1.47	1	5
cosyHouse	134	3.92	0.96	1	5
blocksLessReal	134	2.70	1.25	1	5
reallyInGame	134	2.47	1.25	1	5
loseTrackTime	134	3.49	1.12	1	5
mobsAnnoying	134	3.69	1.15	1	5
nervous	134	3.11	1.25	1	5
modelsFeelReal	134	2.46	1.19	1	5

Table 4.13: Minecraft play style descriptive statistics, EVS2.

Statistic	N	Mean	St. Dev.	Min	Max
buildDecorate	371	3.60	1.01	1	5
realModels	370	2.11	1.08	1	5
redstone	370	2.68	1.23	1	5
exploreCaves	371	3.39	1.09	1	5
dontGetLost	369	3.36	1.22	1	5
useMods	368	3.13	1.51	1	5
cosyHouse	369	3.81	1.08	1	5
blocksLessReal	368	2.97	1.28	1	5
reallyInGame	369	2.37	1.14	1	5
loseTrackTime	367	3.38	1.11	1	5
mobsAnnoying	370	3.82	1.00	1	5
nervous	369	2.79	1.23	1	5
modelsFeelReal	369	2.39	1.23	1	5

Table 4.14: Minecraft play style descriptive statistics, MA.

Statistic	N	Mean	St. Dev.	Min	Max
buildDecorate	47	3.72	0.83	2	5
realModels	47	2.28	0.99	1	5
redstone	47	2.51	0.95	1	5
exploreCaves	47	3.04	1.14	1	5
dontGetLost	47	3.72	1.16	1	5
useMods	47	2.64	1.54	1	5
cosyHouse	47	3.66	1.05	1	5
blocksLessReal	47	3.02	1.22	1	5
reallyInGame	47	2.89	1.31	1	5
loseTrackTime	47	3.94	1.03	1	5
mobsAnnoying	47	3.72	1.14	1	5
nervous	47	3.21	1.02	1	5
modelsFeelReal	47	2.72	1.25	1	5

CHAPTER 5

DEVELOPMENT OF THE REASONS FOR PLAYING VIDEO GAMES MEASURE

One of the main limitations of the EVS1 study was the lack of an empirically grounded measure of reasons for playing games. Though there are several existing measures of gaming motivation, they focus on broad motivational tendencies. Lucas & Sherry (2004)'s uses and gratifications approach yielded six components of gaming motivation (competition, challenge, social interaction, diversion, fantasy, arousal), while Colwell (2007) identified only four (companionship, preferring playing games to being with friends, fun/challenge, stress relief). Chou & Tsai (2007)'s study of Taiwanese high school students also identified four factors, but with different content (entertainment, seeking information, filling time, social reasons). Demetrovics et al. (2011)'s motives for online gaming questionnaire (MOGQ) was developed from empirically-derived items which indicated a 9-factor structure, reduced to 7 factors (social, escape, competition, coping, skill development, fantasy, recreation) by a combination of exploratory and confirmatory factor analysis.

I take a similar approach to Demetrovics et al., but focus on immediate, salient emotional and situational motivations rather than broad motivational profiles. This approach is more consistent with mood management theory, which posits that media choice is determined by the current affective state of the media user (Bryant & Zillmann, 1984; Knobloch-Westerwick, 2006; Zillmann, 1988). Researchers have only recently begun to apply mood management theory to video games; Bowman & Tamborini (2015)'s experimental study of 64 participants compared the effects of task demand in video games on mood recovery for bored or stressed individuals, and several others have begun to investigate the role of the flow experience in mood adjustment and stress relief (Cowley, Charles, Black, & Hickey, 2008; Hull, Williams, & Griffiths, 2013; Jin, 2012). To my knowledge, however, there are no existing measures that capture the variety of proximate motivations for playing video games.

Figure 5.1 provides a map of the relationships between the various RPVG datasets. As described briefly in the EVS2 study in Chapter 3 and in more detail in this chapter, I first conducted an open-response questionnaire study of 54 gamers. Their responses were used to generate the RPVG-60, which was then administered to a new online sample of 243 gamers. The RPVG-23, the measure used in the EVS2 study, was developed by removing items with low facility and high

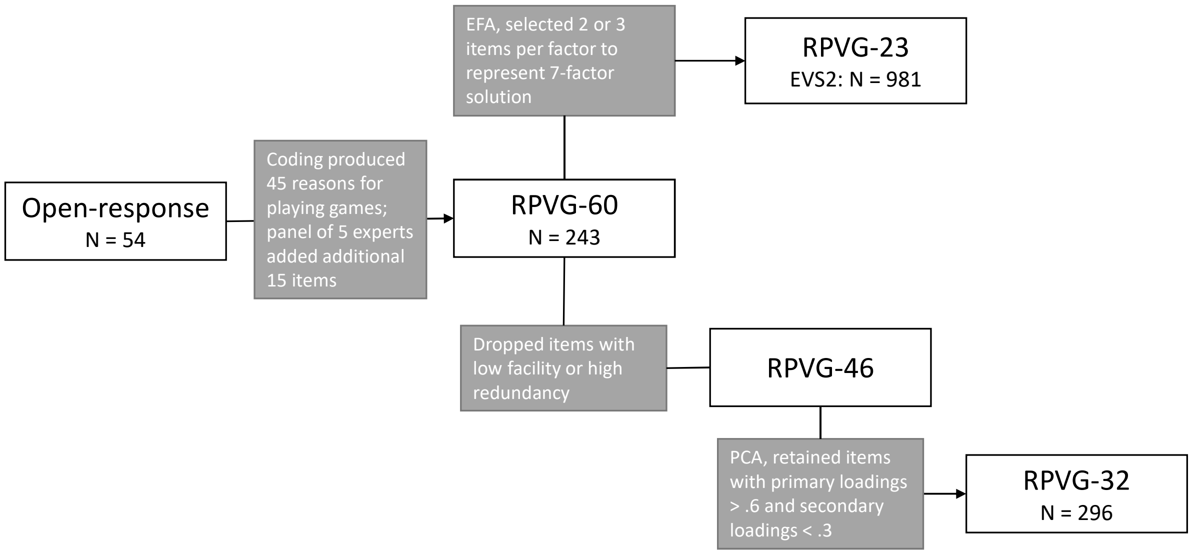

Figure 5.1: Evolution of the Reasons for Playing Games (RPVG) item sets.

redundancy, conducting an exploratory factor analysis, and selecting two or three items with the best face validity to represent each of the factors. These factors were escape/distraction, adventure, social/team, achievement, aggression/violence, motivation/reward, and creative/building; see the appendix for a complete list of items. The expected factor structure did not replicate perfectly in the EVS2 study, however. The escape/distract factor split into two separate factors, while the aggression/violence and motivation/reward factors merged into a single factor.

Because psychological network analysis has only recently been developed, I did not discover it until early 2018. Before this, I experimented with several data reduction and analysis techniques including exploratory and confirmatory factor analysis and principal components analysis; these varied approaches resulted in the three versions of the RPVG datasets outlined in Figure 5.1.

Study 1: Item Development

Methods

I recruited 54 adult self-identified gamers via online gaming forums and asked them to describe their reasons for playing games in their own words. Participants were directed to the survey on Qualtrics.com and were asked to think back to the last time they played a video game, whether it was a console game, a computer game, an online browser game, or a smartphone game, and to respond to five questions: 1). Why did you decide to play a game just then? 2). Why did you choose that particular game? 3.) How were you feeling before you started playing? 4). How did you feel while you were playing? and 5). How did you feel after you finished playing?

While the topic of interest was why participants played games, we also asked about how participants felt before, during and after playing to help us understand and interpret their other responses. These responses were later coded as positive (e.g."excited","calm"), negative (e.g. "stressed", "guilty", "bored"), neutral (e.g. "the same as always"), and mixed ("satisfied but frustrated").

The responses were coded by two assistants with experience playing video games, with the aim of capturing the breadth of responses rather than tight intercoder reliability. The assistants were told to summarise the text in a few words and shown an example but were not otherwise trained or guided by the researcher. Synonyms and common stems were later recoded by the researcher to maximise consistency without sacrificing nuance (e.g. "boredom" and "bored" both recoded as "bored", "fun" and "enjoyment" recoded as "enjoyment", etc). Percent agreement between the two coders was 81%.

Results

Why did you decide to play a game just then?

Responses ranged in length from a word or two (e.g. "boredom" , "To rest") to a few sentences ("It was around 10pm and I was feeling stressed from all of my assignment deadlines and thought, Why not. I'm going to pull an all-nighter tonight anyway. So I started up Splatoon and played for a couple of hours and continued to do homework until 5am. I played until 12am. I would have not played the game as long as I did if my friend did not join me. It's a game that rarely fails to elevate my mood.")

Many respondents identified distraction and escapism as primary reasons for playing, noting that video games are more immersive than films or television and thus a more effective distraction:

"My mind was running and I was over thinking things I shouldn't even be thinking about and wanted a distraction." "I had quite a few real-world responsibilities on my mind: it was nice to get away from them for an hour or two, and I can absorb myself more completely in a game than in a film or TV show."

Immersion was not seen as just a means for distraction or escape, however. Other participants described the world and story of the game as a pleasurable destination:

"It takes me away into a different world. I feel excited and upbeat to be participating in online gaming, and am comfortable interacting with people in that way." "I wanted to experience the world and the story in the game."

Not all participants focused on immersion. Achievement, such as completing timed challenges or collecting rare items, was another common reason for playing.

"To complete a daily challenge within the game." "There are collectibles in the game that take a few hours before the player can take action to collect it. I was aware that it would be finished at the time I started playing, so I could go into the game, play a few levels and collect another item."

In general, responses aligned with the factors we expected (escapism, immersion, achievement, socialising, relaxation, boredom), but there were some unexpected answers as well. One participant reported using gaming as motivation for real-life achievement: "I play counter strike, and every time I die I use it as an excuse to do pushups or pullups to get stronger IRL [in real life]." Stress relief was a common thread, and participants reported consciously using games to escape or relieve stress: "Playing makes you relieve stress of outside world."

Statistically, the most common reason for playing a game was boredom (reported by 10 of 54 participants), followed by a desire to escape from real life (reported by 9 participants). Other common reasons, in order of most occurrences, included "had time to play", "to do something immersive", "for achievement", "for fun", "to relax", "for entertainment" and "for distraction." Question 1, "Why did you decide to play a game just then?" received a total of 45 unique codes, almost as many as there were participants, reflecting the great diversity of reasons.

Mood Patterns

How did you feel before playing?

"I was feeling like the world was caving in around me. I had a lot of work to complete for classes I cannot fail and that day was not a very productive day for many reasons."

Nearly 60% (32 of 54) of participants reported a negative mood such as stress, anxiety, fatigue, or boredom before they started playing. Sixteen participants had a positive mood, 3 felt neutral, and 3 reported mixed emotions ("Excited about playin but guilty about not using my time for more productive things"). The top ten most common moods before gaming were "bored", "excited to play", "tired", "frustrated with real life", "stressed", "good", "anxious", "calm" and "restless."

How did you feel while you were playing?

"Relaxed and at my peak." … "I feel a sense of freedom and excitement that I don't get in every day life." … "Depending on the game, sometimes stressed over how attacked I was in game, sometimes happy, sometimes they drop an emotional bomb and I end up crying, or just doin[g] stuff without much thinking" … "I felt that everything was going to be okay. I was getting pumped up, energized, a little cocky even. Me doing good in Splatoon gave me confidence that the week will be okay because while I was playing I was also planning out my work schedule. Making strategies of how I will distribute the use of my time throughout the week to meet important deadlines."

83% of participants (45 of 54) reported a positive mood while gaming. Only two participants had a negative mood while gaming, one who simply responded "bored" and the other felt guilty for neglecting their studies. Four participants reported a neutral mood, while three reported mixed emotions (e.g. "I was feeling relaxed, angered and soothed between various difficulties of the levels I was playing.") The most common mood while playing was "immersed", reported by

14 of the 54 respondents, followed by “excited”, “energized”, “entertained”, “happy”, “good”, “invested” and “carefree.”

How did you feel when you were finished playing?

“Balanced. On one side I felt happier and pleased with what I’d achieved. But it can make you tired. Sometimes the adrenaline eases off after you’ve finished, and they can be a come down. That could contribute to tiredness and lethargy.” ... “Physically tired, but the mental stress of work, responsibility, and family life melt away when I’m going transported to an alternate reality for just that short time. It’s fun, but time to go to bed.”

About 63% (34 of 54) of participants reported a positive mood after they finished playing, 20% (11 of 54) reported a negative mood, 5 were neutral and 4 were mixed (“satisfied but frustrated”). The most commonly reported post-gaming moods were “satisfied” (14 of 54), “good”, “sleepy”, “sense of accomplishment”, “happy”, “ready for real life”, “sad to stop playing”, and “calm.” Eighteen participants began with a negative mood which improved during gaming and persisted after they were finished playing. Six participants who started with a negative mood felt better during gaming but returned to a negative mood afterward, while 8 participants reported positive moods at all three points. Only two participants reported negative mood throughout, and one participant began with a positive mood, continued to feel good while gaming, and experienced a negative mood after playing (they had been playing at a friend’s house and felt “bummed because I had no games at home”).

Study 2: Pilot and Principal Components Analysis

Method

The 45 reasons for playing games identified in Phase 1 were presented to a panel of five individuals with experience playing games and asked to suggest any additional reasons they felt were not represented. An additional 15 reasons were identified. The final bank of 60 items (see Appendix) was then administered to an online sample of 300 adult self-identified gamers recruited via gaming forums.

Participants

Most participants were 25-34 years old, though nine reported their age as 55 or older. Of those who indicated, 266 (89%) were male, 16 (5%) were female, and 3 reported their gender as non-binary. A total of 26 countries were represented in the sample, with the majority from the UK (N = 145) and US (N = 40). Most participants reported playing several hours per day (N = 138) or a few hours per week (N = 143), with only 9 playing a few times per month or very rarely. 203 (68%) played on a computer, 77 (26%) on a console, 8 on mobile, and 11 did not select a preference.

Procedure and measures

Participants were directed to the survey on Qualtrics.com, informed that they would be asked questions about the reasons they play video games, and asked to confirm that they were at least 18 years old. After providing electronic consent, participants provided their age (by selecting an age bracket, e.g. 18-25, etc.), gender, and country of residence. They were then asked how often they play games (e.g. I spend several hours playing games every day; I play games a few times a month), and which gaming console they prefer.

Participants were then presented with the main item bank, which was a 60-item matrix with the answer options "never, rarely, sometimes, often, always." Participants were encouraged to answer every question, but were able to leave items blank if they wished. All items were formatted as possible completions to the phrase "I play games. . . " and include "to be somewhere else for a while; to reduce stress by doing something relaxing; when I'm feeling angry." The full list of items is included in the appendix.

Data Preparation Demographic variables were missing about 3% of data, and the RPVG items were missing about 20%. Some respondents clicked on the survey link, filled in the first few items, and then quit the survey. The majority of participants missing data were missing over 90%. Inspection of patterns of missing data indicated that most participants who completed the first few items (i.e. the demographics items) went on to complete the entire survey; there was no fatigue drop-off. Consequently, I decided to drop the 56 participants missing over 90%.

Age and gameplay frequency were complete variables included as predictors, while gender, console and country name were omitted from the multiple imputation data set. Predictive mean matching was used to impute the 60 RPVG items. The algorithm showed healthy convergence after 5 iterations. I computed the pooled correlation matrix and saved the first of 5 imputed datasets as complete data (N = 243).

Item Reduction

Item Facility Items with low facility, i.e. means approaching the extreme low score (mean < 2) were "for erotic pleasure", "when I'm feeling angry", "to get ready for bed", "for sexual gratification", "to do speed runs", "for the adrenaline rush of being scared" and "to help me wake up in the morning". The only item with a mean approaching the high end of the scale (mean > 4) was "for fun". These eight items were dropped.

Principal Components Analysis I used several methods to determine the number of components to retain, including visual inspection and non-graphical solutions of the scree test (Raiche, 2010), parallel analysis with simulated data and factor interpretability. I also employed Revelle and Rocklin's Very Simple Structure procedure, which compares the fit of several factor analyses with a "simplified" loading matrix, created by deleting all except the c greatest loadings per item, where c is a measure of factor complexity (Revelle & Rocklin, 1979). The `vss` command in the *psych* packagage also computes Velicer's Minimum Absolute Partial correlation criterion (MAP) (Velicer, 1976), which achieved a minimum of 0.01 with 8 factors, sample size adjusted

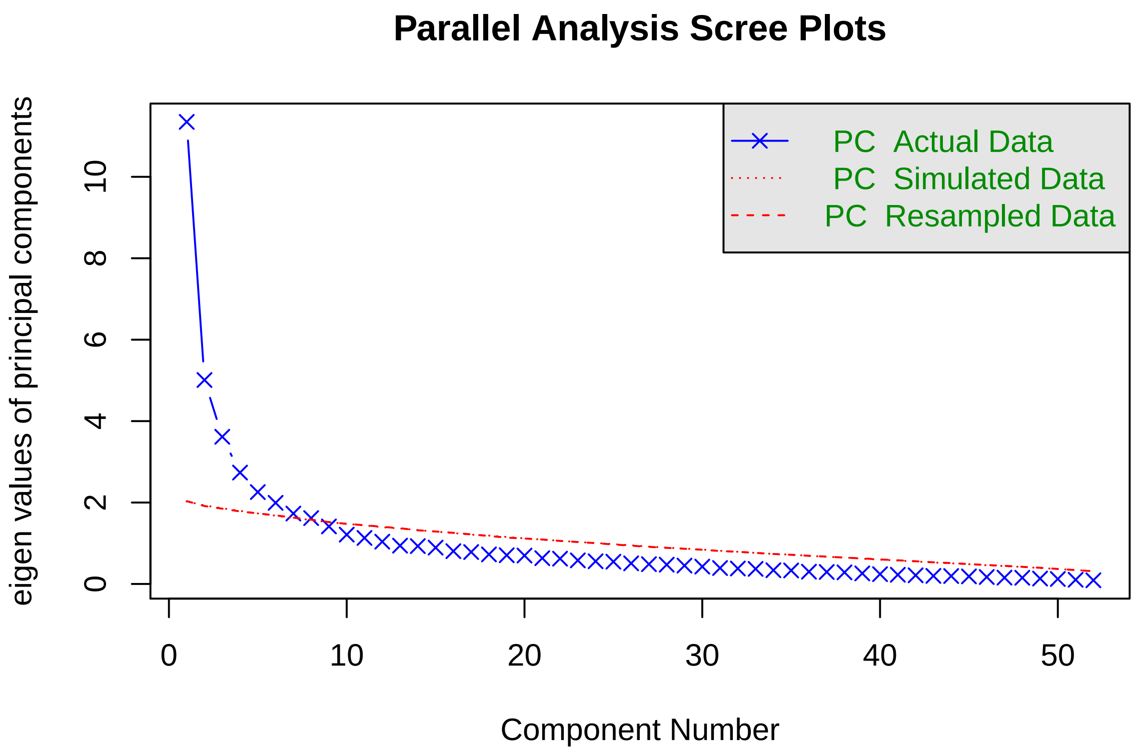

Figure 5.2: Parallel analysis of the 52 RPVG items suggesting 8 components.

BIC, which achieved a minimum of -400 with 8 factors, and additional statistics, which are all presented in Table 5.1.

Parallel analysis with simulated data also indicated extracting 8 components (Figure 5.2). I conducted the principal components analysis using the *psych* package in R, applying promax rotation to amplify loadings and differentiate between components (Bryant & Yarnold, 1995; Matsunaga, 2010). The components were interpretable as Escape, Social, Adventure, Bored, Relax, Energy, Achieve and Create. Component loadings are shown in Table 5.2.

I then dropped the items with primary loadings < 0.6 and secondary loadings > 0.3 (Matsunaga, 2010). These were "roleplay", "compete", "enjoyFamiliarity", "nothingOnTV", "procrastinate", "adrenalineRushExcited", "nostalgia", "inControl", "exploreNew", "feelingStressed", "feelingAnxious", "inspiration", "interactive", "breakFromWork."

Finally, I removed six items which were highly correlated with similarly-worded counterparts (e.g. "to connect with friends" and "to play with friends"), leaving 32 items.

The Escape subscale consisted of 5 items ($\alpha = .84$), the Social subscale had 4 items ($\alpha = .84$), the Adventure subscale also had 4 items ($\alpha = .82$), the Relax subscale had 3 items ($\alpha = .70$), the Energy subscale had 5 items ($\alpha = .70$), the Achieve subscale had 4 items ($\alpha = .64$), the Create subscale had 3 items ($\alpha = .70$), and the Boredom subscale had 4 items ($\alpha = .68$).

Table 5.1: Fit indices and statistics by number of components

	dof	chisq	prob	sqresid	fit	RMSEA	BIC	SABIC	eChisq	SRMR	eCRMS	eBIC	eRMS
1	1274.00	5084.54	0.00	76.24	0.63	0.12	−1913.62	2124.78	10366.99	0.13	0.13	3368.83	0.13
2	1223.00	4051.40	0.00	51.41	0.75	0.10	−2666.61	1210.12	5849.25	0.10	0.10	−868.76	0.10
3	1173.00	3259.04	0.00	38.56	0.81	0.09	−3184.32	533.92	3657.86	0.08	0.08	−2785.51	0.08
4	1124.00	2853.09	0.00	31.43	0.85	0.09	−3321.11	241.81	2647.26	0.06	0.07	−3526.94	0.06
5	1076.00	2560.90	0.00	26.55	0.87	0.08	−3349.63	61.13	2027.89	0.06	0.06	−3882.64	0.06
6	1029.00	2290.05	0.00	22.73	0.89	0.08	−3362.31	−100.53	1564.67	0.05	0.06	−4087.69	0.05
7	983.00	1991.38	0.00	19.86	0.90	0.07	−3408.30	−292.33	1214.97	0.04	0.05	−4184.71	0.04
8	938.00	1779.17	0.00	17.41	0.91	0.07	−3373.32	−400.00	944.41	0.04	0.05	−4208.08	0.04

Table 5.2: Principal components analysis of the 52 Reasons for Playing Games items

Variable	RC1	RC3	RC2	RC5	RC7	RC4	RC8	RC6	h2	u2	com
somewhereElse	**0.67**	0.19	-0.18	-0.06	-0.03	-0.09	0.08	-0.08	0.56	0.44	1.45
partOfTeam	0.03	0.01	**0.76**	0.07	0.04	-0.24	0.10	0.02	0.64	0.36	1.27
reduceStressAggression	0.25	-0.04	0.20	0.11	**0.66**	-0.28	-0.03	0.05	0.66	0.34	1.99
getAchievements	0.05	-0.14	0.06	-0.02	0.06	-0.07	0.00	**0.84**	0.72	0.28	1.10
enjoyBeauty	-0.06	**0.59**	-0.15	0.11	0.00	-0.26	0.03	0.24	0.47	0.53	2.03
rest	-0.01	0.10	-0.04	**0.78**	-0.18	0.05	-0.03	0.05	0.59	0.41	1.16
relaxBeforeBed	-0.01	0.10	0.03	**0.68**	-0.05	0.18	-0.18	0.12	0.57	0.43	1.42
becauseFriendsPlay	-0.19	-0.11	**0.71**	0.10	0.11	0.16	-0.15	0.09	0.64	0.36	1.54
reduceStressRelax	0.21	-0.06	0.14	**0.68**	0.05	-0.13	-0.02	-0.12	0.56	0.44	1.46
roleplay	0.13	**0.65**	0.00	0.23	-0.12	-0.12	-0.28	0.03	0.50	0.50	1.93
education	0.07	**0.62**	0.29	0.01	**-0.32**	-0.02	-0.30	-0.05	0.43	0.57	2.56
distractFromWorries	**0.86**	-0.19	0.02	0.10	0.00	-0.05	-0.03	0.01	0.68	0.32	1.13
enjoyViolence	-0.05	0.08	-0.04	**-0.35**	**0.69**	0.05	0.18	0.04	0.49	0.51	1.72
compete	0.04	-0.21	**0.53**	0.05	-0.05	-0.03	0.28	0.18	0.51	0.49	2.21
collectItems	0.04	0.06	-0.04	0.00	0.03	0.08	0.08	**0.68**	0.54	0.46	1.09
beSomeoneDifferent	**0.58**	0.28	-0.03	-0.07	0.11	-0.10	-0.09	0.09	0.56	0.44	1.75
enjoyFamiliarity	0.23	0.17	-0.07	-0.05	0.00	0.27	0.27	0.11	0.41	0.59	4.26
beCreative	0.03	**0.63**	0.23	-0.15	0.00	-0.02	0.16	-0.17	0.53	0.47	1.73
nothingOnTV	-0.14	0.11	-0.02	0.06	0.18	**0.31**	-0.19	0.29	0.27	0.73	4.23
challenge	-0.05	0.05	0.07	0.16	-0.20	-0.01	**0.52**	0.17	0.43	0.57	1.85
masterSkill	0.11	0.05	0.22	-0.07	-0.14	0.06	**0.50**	0.19	0.52	0.48	2.15
workOutAggression	0.25	-0.08	0.03	-0.08	**0.73**	-0.08	0.09	0.11	0.68	0.32	1.42
procrastinate	0.27	0.00	-0.05	-0.03	0.06	**0.49**	0.00	-0.20	0.38	0.62	1.97
adrenalineRushExcited	0.00	-0.03	0.10	-0.05	**0.33**	-0.04	**0.75**	-0.11	0.66	0.34	1.50
onlineCommunity	0.06	-0.01	**0.71**	0.00	0.03	-0.08	0.09	0.17	0.64	0.36	1.19
convenient	-0.01	0.02	0.28	-0.14	0.00	**0.60**	-0.10	0.00	0.46	0.54	1.61
playWithFriends	-0.15	-0.02	**0.89**	0.01	0.02	0.01	0.04	-0.10	0.78	0.22	1.08
nostalgia	0.04	0.09	0.13	0.19	-0.01	0.15	**0.37**	0.06	0.40	0.60	2.49
relax	-0.04	-0.14	0.02	**0.76**	-0.04	0.09	0.27	-0.11	0.65	0.35	1.42
freeTime	-0.13	-0.03	-0.19	0.28	-0.24	**0.72**	0.14	-0.02	0.58	0.42	1.88
escape	**0.84**	0.04	-0.14	0.05	-0.02	-0.04	0.05	0.01	0.76	0.24	1.09
feelingSad	**0.72**	0.00	-0.05	0.16	0.06	0.16	-0.03	-0.09	0.67	0.33	1.27
distractFromLife	**0.93**	-0.09	-0.04	-0.01	0.03	0.10	-0.06	-0.04	0.83	0.17	1.06
build	0.15	**0.65**	**0.31**	-0.20	-0.15	0.13	-0.12	-0.02	0.60	0.40	2.06
inControl	**0.51**	0.26	0.02	-0.25	0.00	0.07	0.10	0.06	0.51	0.49	2.21
exploreNew	0.14	**0.63**	-0.17	0.04	-0.09	-0.09	0.30	-0.02	0.66	0.34	1.85
feelingStressed	**0.49**	-0.11	0.03	**0.42**	0.26	-0.04	-0.04	-0.01	0.65	0.35	2.67
excitement	-0.13	0.12	-0.06	0.00	0.23	0.06	**0.74**	-0.02	0.66	0.34	1.35
feelingAnxious	**0.56**	-0.02	-0.13	0.18	0.18	0.13	-0.09	0.08	0.55	0.45	1.79
waiting	0.06	0.01	-0.06	0.07	0.11	**0.66**	0.00	0.12	0.55	0.45	1.18
adventure	-0.14	**0.66**	-0.20	0.00	0.11	-0.01	**0.32**	0.02	0.64	0.36	1.83
experienceStory	-0.28	**0.72**	-0.19	0.03	**0.31**	0.01	-0.02	-0.03	0.56	0.44	1.89
ignoreSurroundings	**0.75**	-0.08	-0.03	-0.14	0.21	0.16	-0.05	0.06	0.69	0.31	1.39
feelingBored	0.18	-0.16	-0.04	-0.02	-0.10	**0.76**	0.07	0.05	0.57	0.43	1.29
connectFriends	-0.11	0.00	**0.88**	-0.01	0.11	0.01	0.02	-0.06	0.79	0.21	1.07
inspiration	0.00	**0.58**	0.21	-0.05	0.21	-0.02	0.09	-0.05	0.53	0.47	1.66
interactive	-0.03	**0.38**	0.13	0.14	-0.19	0.19	**0.38**	-0.19	0.54	0.46	4.06
breakFromWork	0.05	0.04	0.20	0.10	**0.49**	0.21	0.01	-0.21	0.52	0.48	2.28
energized	0.06	0.22	0.06	0.16	**0.46**	-0.06	0.29	-0.10	0.57	0.43	2.78
motivate	-0.18	0.26	0.09	0.26	**0.40**	0.07	0.06	0.08	0.48	0.52	3.34
getAllAchievements	-0.07	0.03	0.00	-0.04	0.02	0.10	-0.05	**0.86**	0.72	0.28	1.06
experienceWorld	-0.15	**0.81**	-0.19	0.01	0.13	-0.03	0.13	0.01	0.69	0.31	1.30
SS loadings	5.89	5.18	4.37	3.1	3.17	2.89	3.19	2.51			
RC1	1.00	0.41	0.09	0.22	0.35	0.17	0.23	0.19			
RC3	0.41	1.00	0.15	0.23	0.22	0.25	0.38	0.24			
RC2	0.09	0.15	1.00	0.14	0.11	0.20	0.26	0.30			
RC5	0.22	0.23	0.14	1.00	0.34	0.19	0.14	0.14			
RC7	0.35	0.22	0.11	0.34	1.00	0.30	0.07	0.07			
RC4	0.17	0.25	0.20	0.19	0.30	1.00	0.20	0.08			
RC8	0.23	0.38	0.26	0.14	0.07	0.20	1.00	0.20			
RC6	0.19	0.24	0.30	0.14	0.07	0.08	0.20	1.00			

Study 3: Replication and Confirmatory Factor Analysis

To assess the validity of the RPVG-32 and investigate whether the factor structure was stable, I administered the RPVG-32 to an online sample of 296 adult self-reported gamers.

Method

Participants

I recruited 296 participants (244 men, 42 women, 10 other or preferred not to say) via online gaming forums. The majority reported playing games several hours per day (N = 168) or a few hours per week (N = 119), with 10 participants playing games only a few times a month or very rarely. 55% were primarily computer gamers, 38% were console gamers, and 7% played primarily on a mobile or handheld device.

Genre and RPVG

As with the EVS2 study, participants indicated their genre preference by selecting how often they played each of 13 genres on a 5-point scale ranging from "never" to "always". Adventure with combat, RPG (role-playing game) and shooter were the most popular genres, while casual, racing and sports were the least popular (means and other descriptives are included in the appendix).

Full descriptive statistics for the RPVG-32 items are presented in the appendix. The items associated with immersion in the world and story had the highest means, while violence and education had the lowest.

Results

Reliability

Cronbach's $\alpha = .83$ for the Escape subscale, .82 for the Social subscale, .84 for the Adventure subscale, .67 for the Energy subscale, .67 for the Relax subscale, .68 for the Achieve subscale, .7 for the Create subscale, and .63 for the Boredom subscale.

Confirmatory Factor Analysis

I fit the model using lavaan version 0.6-1 (Rosseel, 2012), with maximum likelihood estimation and standardised latent factors (Jöreskog, 1969). The model fit was acceptable but not excellent, with a TLI of 0.821 and RMSEA of 0.064, 90% CI(0.059, 0.070), though the 8-factor model fit significantly better than a single-factor solution, $\chi^2(28) = 1153, p < .001$ (Bentler & Bonett, 1980; Hu & Bentler, 1999).

As shown in Table 5.4, nearly all of the factors were correlated with each other, some to a very high degree, especially the Energy, Social, and Achieve factors.

Table 5.3: Factor Loadings of the RPVG-32 Confirmatory Factor Analysis

	Latent Factor	Indicator	B	SE	Z	Beta	sig
1	ESC	somewhereElse	0.92	0.07	14.10	0.74	***
2	ESC	distractFromWorries	1.06	0.06	16.40	0.82	***
3	ESC	beSomeoneDifferent	0.75	0.08	9.06	0.52	***
4	ESC	feelingSad	0.90	0.07	12.64	0.68	***
5	ESC	ignoreSurroundings	1.11	0.07	15.44	0.79	***
6	SOC	partOfTeam	1.06	0.07	15.96	0.82	***
7	SOC	becauseFriendsPlay	0.82	0.07	11.70	0.65	***
8	SOC	onlineCommunity	0.93	0.07	13.76	0.74	***
9	SOC	playWithFriends	0.92	0.07	12.51	0.69	***
10	ADV	enjoyBeauty	0.74	0.06	12.31	0.67	***
11	ADV	adventure	0.83	0.06	15.07	0.78	***
12	ADV	experienceWorld	0.83	0.05	16.05	0.82	***
13	ADV	experienceStory	0.78	0.06	13.97	0.74	***
14	RELAX	rest	0.82	0.08	10.76	0.68	***
15	RELAX	relaxBeforeBed	0.70	0.08	8.74	0.56	***
16	RELAX	reduceStressRelax	0.72	0.07	10.46	0.66	***
17	ENERG	energized	0.89	0.07	13.15	0.72	***
18	ENERG	motivate	0.66	0.08	8.45	0.50	***
19	ENERG	excitement	0.52	0.06	9.27	0.54	***
20	ENERG	reduceStressAggression	0.85	0.08	10.82	0.61	***
21	ENERG	enjoyViolence	0.36	0.07	5.23	0.32	***
22	ACH	getAchievements	0.51	0.08	6.62	0.41	***
23	ACH	collectItems	0.63	0.07	8.97	0.54	***
24	ACH	masterSkill	1.01	0.08	13.32	0.75	***
25	ACH	challenge	0.68	0.06	10.94	0.64	***
26	CREA	education	0.53	0.07	8.07	0.49	***
27	CREA	beCreative	1.05	0.07	14.81	0.85	***
28	CREA	toBuild	0.76	0.07	11.38	0.67	***
29	BORE	convenient	0.53	0.08	6.32	0.42	***
30	BORE	feelingBored	0.54	0.06	9.03	0.58	***
31	BORE	waiting	0.74	0.07	9.95	0.64	***
32	BORE	freeTime	0.61	0.07	9.12	0.59	***

Table 5.4: Correlation matrix of the 8 RPVG factors, N=296

	Escape	Social	Adventure	Create	Relax	Bored	Achieve
Escape							
Social	0.30***						
Adventure	0.37***	0.33***					
Create	0.36***	0.54***	0.62***				
Relax	0.69***	0.37***	0.43***	0.41***			
Bored	0.46***	0.62***	0.09	0.24***	0.47***		
Achieve	0.44***	0.76***	0.62***	0.69***	0.41***	0.49***	
Energy	0.77***	0.65***	0.65***	0.68***	0.73***	0.53***	0.85***

Factor Correlations with Genre

Table 5.5 shows the correlations between the latent RPVG factors and genre preference.

Table 5.5: Correlations of RPVG CFA Factors with Genre, N=296

	Escape	Social	Adventure	Create	Relax	Bored	Achieve	Energy
adventureCombat	0.20***	0.15*	0.42***	0.23***	0.19***	0.11	0.25***	0.28***
shooter	0.12*	0.37***	0.12*	0.12*	0.14*	0.30***	0.26***	0.24***
sim	0.15*	0.14*	0.27***	0.36***	0.20***	0.11	0.18**	0.23***
casual	0.01	0.01	-0.06	0.07	-0.01	0.07	0.06	0.04
adventureNoCombat	0.04	-0.03	0.18**	0.15**	0.08	-0.09	0.06	0.08
sports	-0.13*	0.11	-0.02	0.08	-0.01	0.03	0.10	0.00
grandStrategy	0.04	0.10	0.22***	0.27***	0.08	0.00	0.12*	0.12*
massivelyMultiplayer	0.08	0.51***	0.18**	0.27***	0.21***	0.29***	0.38***	0.29***
exploration	0.12*	0.08	0.29***	0.25***	0.14*	0.02	0.18**	0.21***
puzzle	0.06	-0.04	0.09	0.16**	0.00	-0.01	0.13*	0.10
RPG	0.15*	0.07	0.42***	0.18**	0.18**	0.00	0.18**	0.21***
sandbox	0.16**	0.12*	0.28***	0.38***	0.12*	0.13*	0.19***	0.22***
racing	-0.09	-0.02	0.07	0.10	0.02	-0.02	0.05	0.00

The racing and casual genres were uncorrelated with the RPVG factors, and the puzzle, sports, and adventure without combat genres only had a few small correlations; this is likely because these genres are more specific and therefore preferred by fewer participants. In contrast, shooter was correlated with all of the factors, and massively multiplayer was correlated with all except Escape. Of all the RPVG factors, Escape was the least associated with genre, with the highest correlation being only $r = 0.20$ with the adventure combat genre.

Appendix

Table 5.6: Full text of the RPVG-60.

Item:	Item (continued):
to be somewhere else for a while	to be part of a team
to reduce stress by working out aggression	to get achievements
to enjoy the beauty of the game environment	to rest
to relax before going to bed	because all my friends are playing
to reduce stress by doing something relaxing	to roleplay
for education/learning	to distract myself from worries
for fun	for erotic pleasure
because I enjoy the violence	when I'm feeling angry
to compete	to collect items
to be someone different from who I am in real life	because I enjoy the familiarity of the game
to be creative	to get ready for bed
for sexual gratification	when there's nothing on TV
to do speed runs	for the adrenaline rush of being scared
for a challenge	to master a skill
to work out aggression	to procrastinate
for the adrenaline rush of being excited	to be part of a community
because it is more convenient than other forms of entertainment	to play with my friends
for nostalgia	to relax
because I have free time	to help me wake up in the morning
to escape	when I'm feeling sad
to distract myself from real life	to build things
to feel in control	to explore somewhere new
when I'm feeling stressed	for excitement
when I'm feeling anxious	to pass the time while I'm waiting
when I'm feeling bored	to connect with friends
for inspiration	when I want to do something interactive
for a break from work or school	to feel energized
as a reward to motivate me for doing something productive	to get all the achievements
to experience the world of the game	to experience a story
to help me ignore my surroundings	

Table 5.7: Descriptive statistics of the RPVG-60

Statistic	N	Mean	St. Dev.	Min	Max
somewhereElse	243	3.10	1.11	1	5
partOfTeam	243	2.37	1.01	1	5
reduceStressAggression	243	2.44	1.10	1	5
getAchievements	243	2.44	1.04	1	5
enjoyBeauty	243	3.66	0.82	1	5
rest	243	3.32	0.96	1	5
relaxBeforeBed	243	2.71	1.12	1	5
becauseFriendsPlay	243	2.24	1.04	1	5
reduceStressRelax	243	3.33	1.01	1	5
roleplay	243	2.65	1.15	1	5
education	243	2.12	0.89	1	4
distractFromWorries	243	3.06	1.10	1	5
fun	243	4.57	0.60	1	5
eroticPleasure	243	1.42	0.78	1	5
enjoyViolence	243	2.15	1.03	1	5
feelingAngry	243	1.86	0.91	1	5
compete	243	2.57	1.08	1	5
collectItems	243	2.60	1.01	1	5
beSomeoneDifferent	243	2.60	1.30	1	5
enjoyFamiliarity	243	3.16	1.01	1	5
beCreative	243	2.92	0.99	1	5
readyForBed	243	1.93	0.99	1	5
sexualGratification	243	1.28	0.66	1	5
nothingOnTV	243	2.70	1.34	1	5
speedRuns	243	1.33	0.61	1	4
adrenalineRushScared	243	1.98	0.96	1	5
challenge	243	3.49	0.83	1	5
masterSkill	243	3.02	1.04	1	5
workOutAggression	243	2.05	1.03	1	5
procrastinate	243	2.77	1.11	1	5
adrenalineRushExcited	243	3.08	1.03	1	5
onlineCommunity	243	2.42	1.04	1	5
convenient	243	3.04	1.16	1	5
playWithFriends	243	2.74	1.12	1	5
nostalgia	243	2.81	0.92	1	4
relax	243	3.57	0.91	1	5
freeTime	243	3.56	0.88	1	5
wakeUpMorning	243	1.41	0.66	1	4
escape	243	2.85	1.29	1	5
feelingSad	243	2.26	1.06	1	5
distractFromLife	243	2.81	1.20	1	5
build	243	2.64	0.98	1	5
inControl	243	2.51	1.11	1	5
exploreNew	243	3.54	0.94	1	5
feelingStressed	243	2.65	1.00	1	4
excitement	243	3.59	0.88	1	5
feelingAnxious	243	2.25	1.08	1	5
waiting	243	2.94	0.93	1	5
adventure	243	3.66	0.92	1	5
experienceStory	243	3.78	0.97	1	5
ignoreSurroundings	243	2.48	1.14	1	5
feelingBored	243	3.51	0.92	1	5
connectFriends	243	2.54	1.07	1	5
inspiration	243	2.37	0.98	1	5
interactive	243	3.40	1.00	1	5
breakFromWork	243	3.16	1.12	1	5
energized	243	2.56	1.08	1	5
motivate	243	2.44	1.16	1	5
getAllAchievements	243	2.06	1.02	1	5
experienceWorld	243	3.86	0.96	1	5

Table 5.8: Descriptive statistics of the RPVG-32

Statistic	N	Mean	St. Dev.	Min	Max
adventure	296	3.91	1.07	1	5
becauseFriendsPlay	296	2.42	1.26	1	5
beCreative	296	3.10	1.24	1	5
beSomeoneDifferent	296	2.93	1.44	1	5
toBuild	296	2.92	1.15	1	5
challenge	296	3.68	1.07	1	5
collectItems	296	2.54	1.18	1	5
convenient	296	3.29	1.27	1	5
distractFromWorries	296	3.51	1.29	1	5
education	296	2.23	1.09	1	5
energized	296	2.62	1.23	1	5
enjoyBeauty	296	3.85	1.10	1	5
enjoyViolence	296	2.09	1.12	1	5
excitement	296	3.83	0.97	1	5
experienceStory	296	4.00	1.06	1	5
experienceWorld	296	4.10	1.01	1	5
feelingBored	296	3.85	0.93	1	5
feelingSad	296	3.05	1.31	1	5
freeTime	296	3.77	1.04	1	5
getAchievements	296	2.46	1.24	1	5
ignoreSurroundings	296	3.10	1.41	1	5
masterSkill	296	2.80	1.35	1	5
motivate	296	2.57	1.33	1	5
onlineCommunity	296	2.52	1.26	1	5
partOfTeam	296	2.65	1.29	1	5
playWithFriends	296	3.20	1.34	1	5
reduceStressAggression	296	2.83	1.39	1	5
reduceStressRelax	296	3.85	1.10	1	5
relaxBeforeBed	296	2.95	1.27	1	5
rest	296	3.12	1.22	1	5
somewhereElse	296	3.67	1.24	1	5
waiting	296	3.15	1.16	1	5

Table 5.9: Descriptive statistics of the genre preference items in the RPVG-32 study

Statistic	N	Mean	St. Dev.	Min	Max
adventureCombat	296	3.70	0.87	1	5
shooter	296	3.49	1.09	1	5
sim	296	2.42	1.05	1	5
casual	296	1.89	0.97	1	5
adventureNoCombat	296	2.50	1.04	1	5
sports	296	1.67	0.95	1	5
grandStrategy	296	2.59	1.22	1	5
massivelyMultiplayer	296	2.65	1.29	1	5
exploration	296	2.31	1.14	1	5
puzzle	296	2.54	1.06	1	5
RPG	296	3.69	1.03	1	5
sandbox	296	3.13	1.06	1	5
racing	296	2.11	1.04	1	5

CHAPTER 6

NETWORK ANALYSIS OF THE RPVG

The use of network analysis to model complex dynamic psychological systems was first suggested by Van Der Maas et al. (2006), and further developed by Borsboom & Cramer (2013), Schmittmann et al. (2013) and Epskamp (2017). Network analysis was originally proposed as an alternative to latent variable models, viewing psychological attributes not as underlying common causes but as complex systems of interacting components. From this perspective, the positive manifolds of phenomena such as intelligence (Van Der Maas et al., 2006), depression (Bringmann, Lemmens, Huibers, Borsboom, & Tuerlinckx, 2015; Fried, Epskamp, Nesse, Tuerlinckx, & Borsboom, 2016) and personality (Costantini et al., 2015) are interpreted as dynamic systems of reciprocal causation.

Psychological network analysis does not preclude latent variables in the system; indeed, there is a direct equivalence between network and latent variable models (Kruis & Maris, 2016; Van Der Maas et al., 2006). Partial correlations retain shared variance unaccounted for by the other variables in the network, including latent variables which should manifest as fully connected clusters of nodes (Epskamp et al., 2018). Latent variables can also be included as nodes themselves, allowing a powerful exploratory approach (Guyon, Falissard, & Kop, 2017).

In this chapter, I discuss the network analyses I performed on three Reasons for Playing Games (RPVG) datasets. Analysis 1 demonstrates the centrality of stress relief as a motivation for gaming and highlights connections within and between the clusters of variables that were obscured by the latent factor analyses in the previous chapter. Analysis 2 investigates the network structure of the RPVG-32, which includes only items with low secondary factor loadings (see Chapter 5, Study 2) and thus omits the variable "I play games when I'm feeling stressed." Analysis 2 also investigates the effects of genre on clustering behaviour. Finally, Analysis 3 presents a network analysis of the version of the RPVG used in the EVS2 study (see Chapter 3, Study 2), and takes an exploratory look at the "big picture" by conducting a latent network analysis that includes both gameplay style and reasons for playing games.

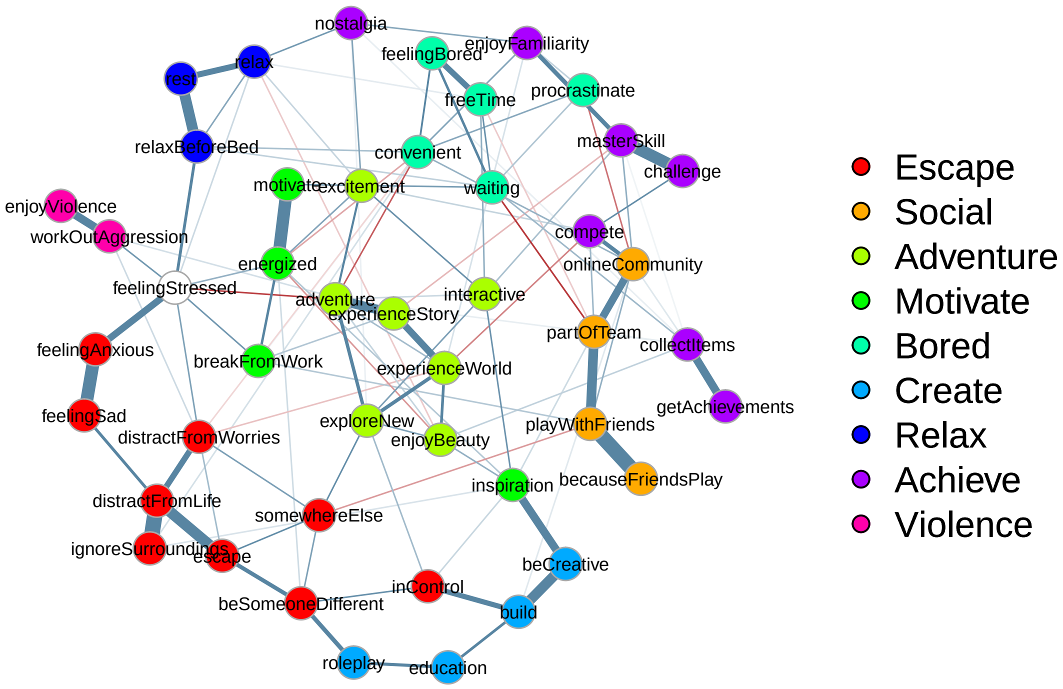

Figure 6.1: Network plot of the 46 reasons for playing video games.

Analysis 1: RPVG-46

I used the *qgraph* package in R to estimate a partial correlation matrix via the adaptive LASSO technique.

As discussed in Chapter 2, the LASSO procedure involves manually setting the hyperparameter γ, which determines the degree to which the EBIC model section prefers sparsity. This value generally varies from 0 to 0.5, with 0.5 being the typically recommended (albeit conservative) value (Epskamp & Fried, 2018). Figure 6.2 compares the best-fitting models under γ values of 0, 0.25 and 0.5. While the network selected when $\gamma = 0$ (top) is noticably noisier, the same general structure can be observed in all three.

The final network, plotted in Figure 6.1, has 112 edges, 99 of which are positive (shown in blue) and 13 of which are negative (shown in red). Edge weight represents the magnitude of correlation and is indicated by line thickness. Positive edges are associated with larger weights (M = .18, SD = .12) than the negative edges (M = .10, SD = .05), and the t-test indicates that this difference is significant, $t(110) = 2.12$, $p = 0.036$. The plot uses the force-directed Fruchterman-Reingold layout, in which positively associated nodes are drawn closer to each other and negatively associated nodes are repelled (Fruchterman & Reingold, 1991).

Nodes are coloured according to their highest-loading factor; because of the significant cross-loading of “feelingStressed” and its central role in the network, it is not grouped with a factor. Nodes are grouped together with their factors, but it is especially interesting to examine the nodes which link separate factors. “I play games to feel in control” loads onto the Escape/Distract

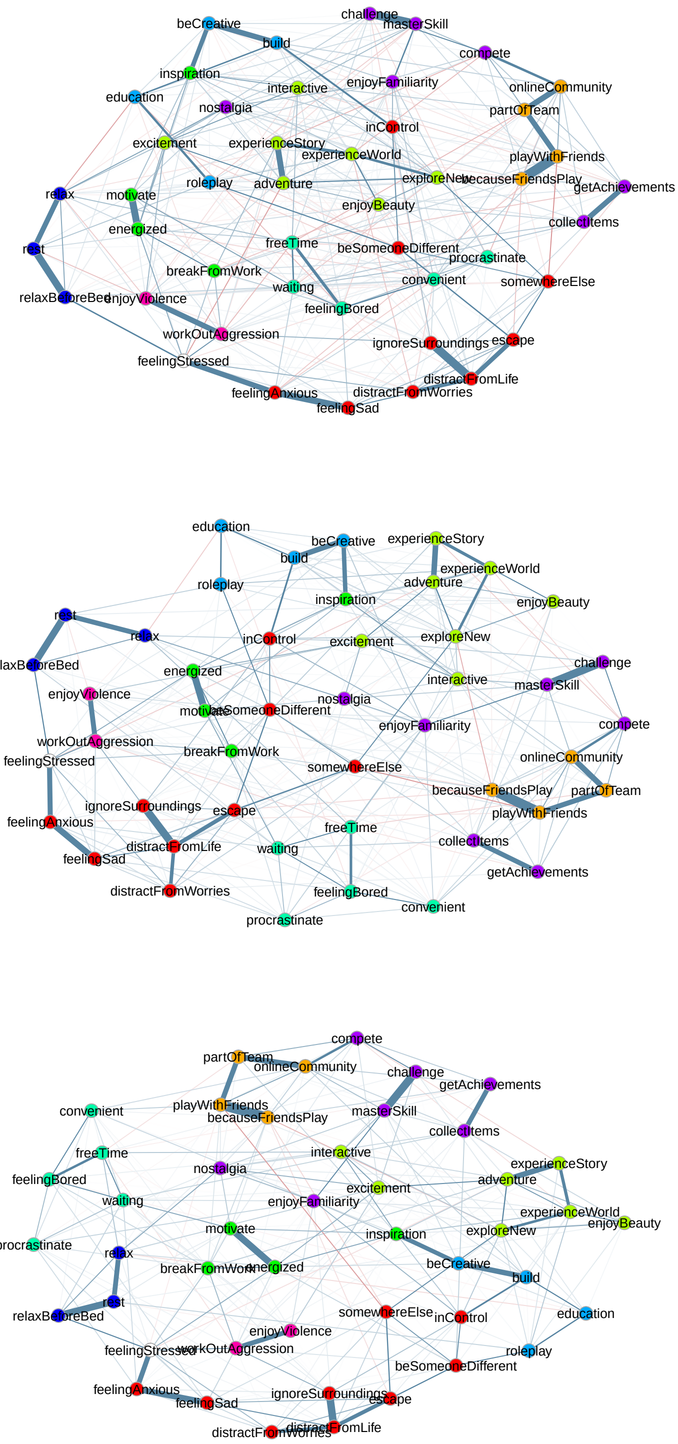

Figure 6.2: Effects of different values of the EBIC hyperparameter, set to 0 (top), 0.25 (center), and 0.5 (bottom).

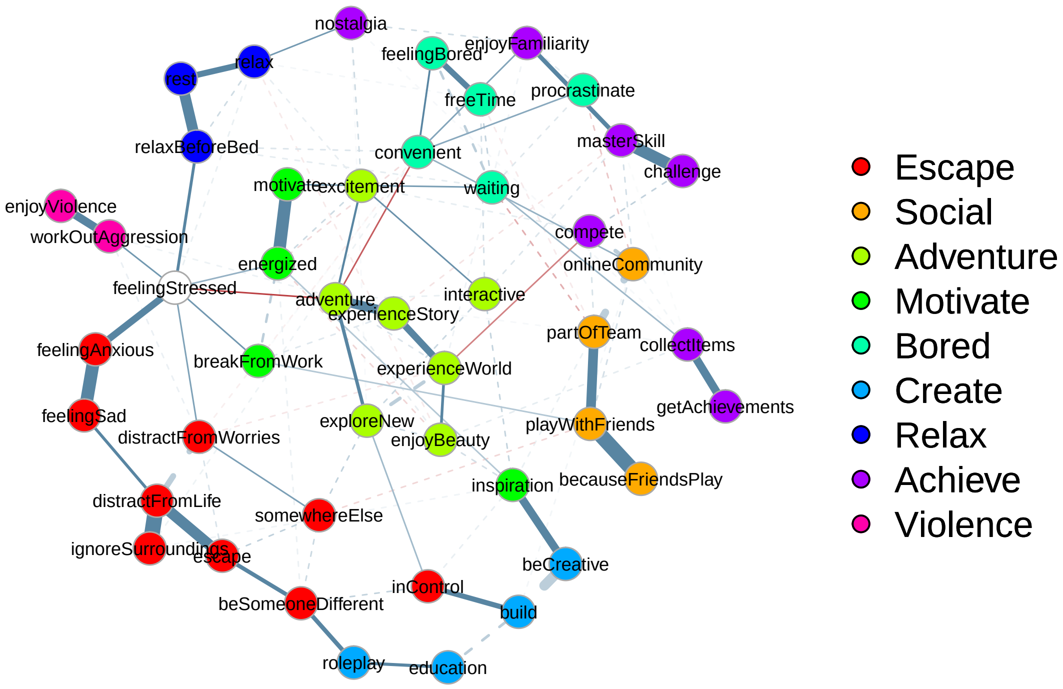

Figure 6.3: Shortest paths through node feelingStressed. Edges belonging to the shortest paths are solid, other edges are dashed.

factor but is also strongly associated with the Create factor via "I play games to build things" and the Adventure factor via "I play games to explore somewhere new".

The most direct links with "feeling stressed" represent different ways in which gaming might relieve stress: by relaxing, working out aggression, as a break from work, to feel energised, and as a distraction from worries or real life. While "feeling stressed" is directly linked to "distract from worries," the link to "distract from real life" is via the "feeling anxious" and "feeling sad" nodes. Figure 6.3 shows only the shortest paths through "feeling stressed".

The majority of edges in the network are positive, but there are a few salient negative edges. "Feeling stressed" is negatively associated with "to have an adventure", which is in turn negatively associated with "I play games because they are convenient". It appears gamers who play for immersion in a world or story are less interested in competition and skill development. When they do play for stress relief, it is for the escape provided by feeling like they are somewhere else for a while.

Centrality

Network analysis does not assume that all nodes are equally important in determining the network's structure, and several indices of importance, or *centrality*, are available to us (Freeman, 1978). The three most common centrality indices are shown in Table 6.1. The *strength* of a node is defined as the sum of the weights of the connections that node has. The nodes with highest strength in our network are "enjoyBeauty", "reduceStressAggression", "distractFromLife", "feelingStressed", and "onlineCommunity". High-strength nodes are those that can influence and be influenced by many other nodes, without considering mediation (Epskamp, 2017, p. 206).

Table 6.1: Centrality scores of the nodes in the RPVG-46.

Node	Variable	Factor	Betweenness	Closeness	Strength
33	feelingStressed		241	1.55	1.42
1	somewhereElse	Escape	**117**	**1.42**	0.79
10	distractFromWorries	Escape	9	1.30	0.88
14	beSomeoneDifferent	Escape	73	1.20	0.91
27	escape	Escape	82	1.27	0.96
29	distractFromLife	Escape	89	1.23	**1.44**
31	inControl	Escape	38	1.17	0.64
39	ignoreSurroundings	Escape	0	1.13	0.60
28	feelingSad	Escape	66	1.28	0.68
35	feelingAnxious	Escape	86	1.36	0.77
2	partOfTeam	Social	**96**	**1.35**	1.17
7	becauseFriendsPlay	Social	0	1.16	0.49
21	onlineCommunity	Social	60	1.31	1.19
23	playWithFriends	Social	80	1.30	**1.19**
4	enjoyBeauty	Adventure	38	1.32	0.81
32	exploreNew	Adventure	128	1.61	1.11
34	excitement	Adventure	47	1.45	0.83
37	adventure	Adventure	**186**	**1.64**	**1.45**
38	experienceStory	Adventure	37	1.49	0.91
46	experienceWorld	Adventure	58	1.50	1.13
42	interactive	Adventure	71	1.41	0.81
41	inspiration	Motivate	83	1.28	0.91
43	breakFromWork	Motivate	16	1.37	0.59
44	energized	Motivate	**89**	**1.48**	**1.28**
45	motivate	Motivate	39	1.38	0.60
20	procrastinate	Bored	0	1.10	0.45
22	convenient	Bored	**120**	**1.49**	**1.09**
26	freeTime	Bored	21	1.23	0.69
36	waiting	Bored	94	1.32	1.05
40	feelingBored	Bored	26	1.30	0.72
8	roleplay	Create	15	1.03	0.49
9	education	Create	10	1.00	0.46
16	beCreative	Create	**58**	**1.17**	0.73
30	build	Create	56	1.14	**0.93**
5	rest	Relax	41	1.21	0.70
6	relaxBeforeBed	Relax	**75**	**1.36**	**0.95**
25	relax	Relax	16	1.10	0.82
3	getAchievements	Achieve	0	0.85	0.35
12	compete	Achieve	35	**1.23**	0.75
13	collectItems	Achieve	**44**	0.96	0.68
17	challenge	Achieve	7	1.06	0.61
18	masterSkill	Achieve	42	1.16	**1.01**
15	enjoyFamiliarity	Achieve	37	1.17	0.68
24	nostalgia	Achieve	16	1.14	0.82
19	workOutAggression	Violence	**44**	**1.12**	0.63
11	enjoyViolence	Violence	0	0.98	0.35

NOTE: The node with the highest centrality score for its group is printed in **bold.**

Closeness is defined as the inverse of the sum of the distances of the focal node from all the other nodes in the network (Epskamp, 2017; Opsahl et al., 2010); in the case of our network, where edge weights correspond to the magnitude of the correlation, weights are converted to lengths/distances by taking the inverse of the absolute weight (Opsahl et al., 2010). Nodes with the highest closeness centrality are "adventure", "feelingStressed", "exploreNew", "enjoyBeauty", "reduceStressRelax", and "experienceWorld".

Betweenness refers to the number of the geodesics between any two nodes that pass through the focal one, where the geodesics between two nodes are the paths that connect them that have the shortest distance. Figure 6.4 shows the network with node size scaled by Betweenness. The node with the highest between-centrality is "feelingStressed"; with a value of 202, "feelingStressed" is

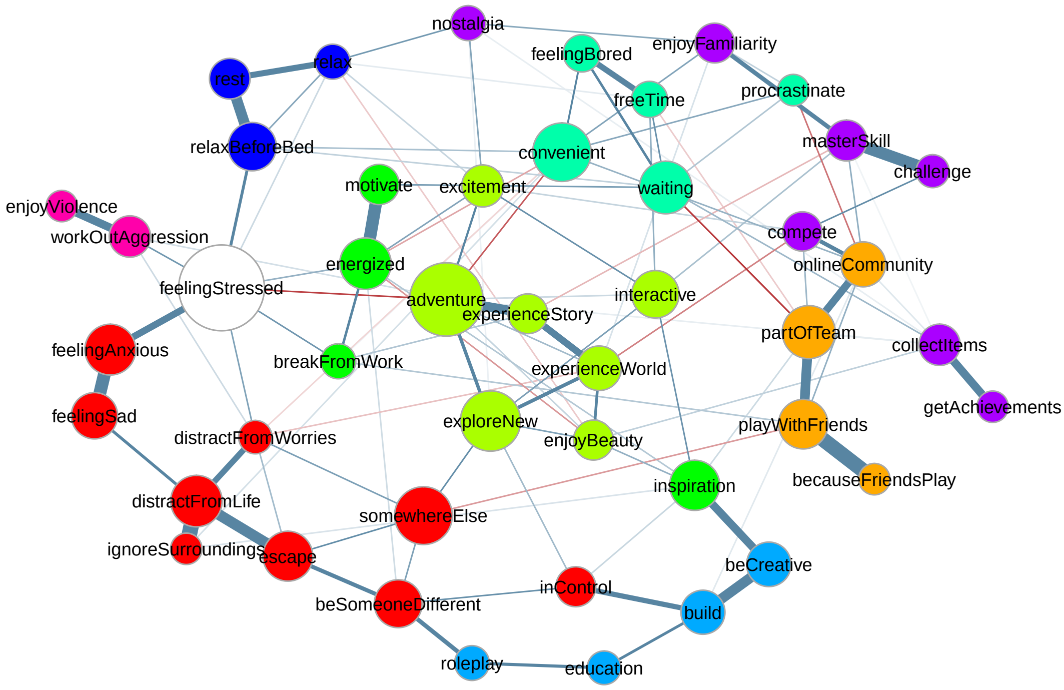

Figure 6.4: Network plot of Reasons for Playing Video Games, with node size scaled by Betweenness

a much more influential node than the next highest node, “adventure”, which has a value of 165.

Clustering

Networks can also be described from the perspective of *clustering*. Each node has a clustering coefficient, defined as the number of connections among neighbours of that node (Watts & Strogatz, 1998). A high clustering coefficient implies redundancy within that node’s neighbourhood; that is, a node which is strongly connected to its neighbours is less likely to have a unique causal role in the network. Of the several clustering measures available, Epskamp found Zhang’s clustering coefficient to be the most resistant to random variations in the network (Epskamp, 2017; Zhang & Horvath, 2005). “I play games to rest” had the highest clustering coefficient by far, with a value of 3.74; no other variable exceeded an absolute value of 1.69, as the next highest were “because I had free time” and “to relax”. *Qgraph* allows us to plot clustering coefficient by centrality index in Figure 6.5. While “rest” has a high clustering coefficient, it lies near the median for each centrality index, suggesting that it does play a role in the network but is redundant with other nodes.

The nodes “feeling bored”, “waiting”, “free time”, and “convenient” are all interconnected in a cluster, suggesting the presence of a latent factor.

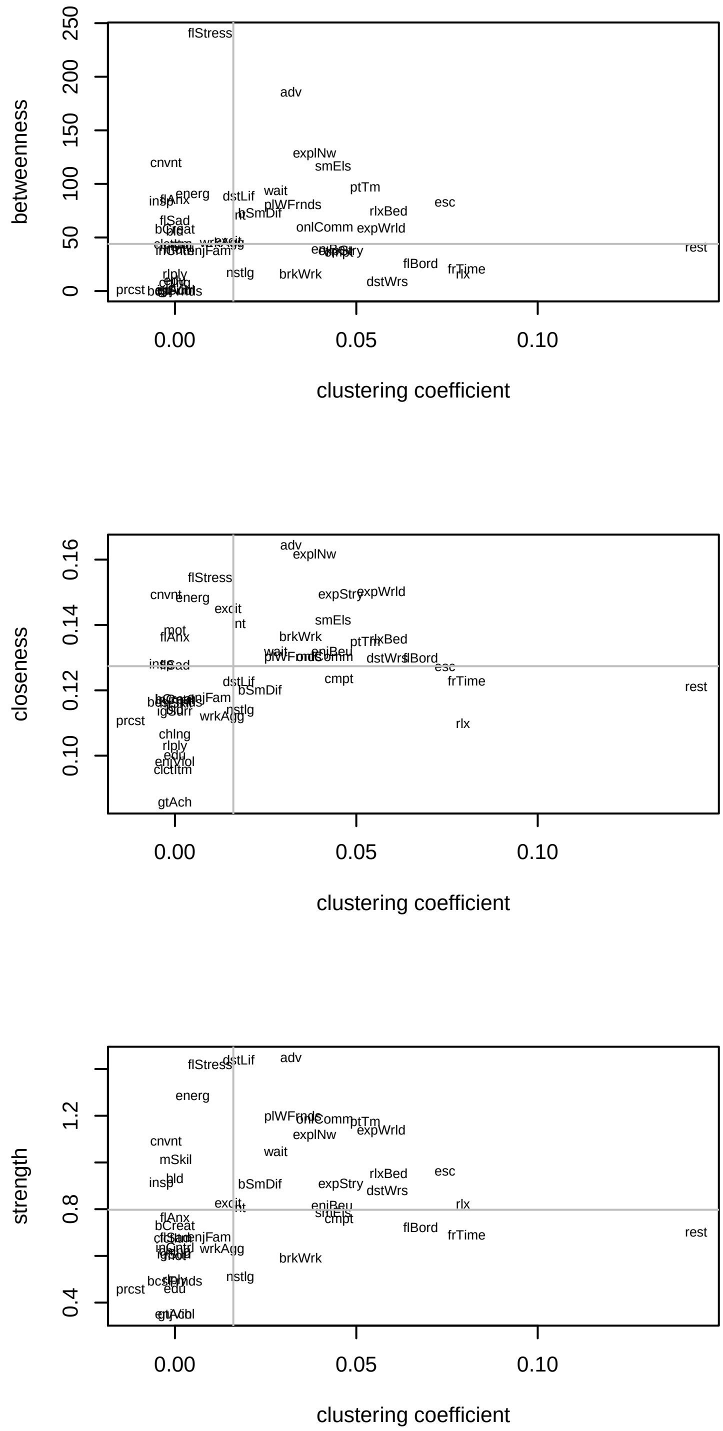

Figure 6.5: Centrality plotted by clustering coefficient. Horizontal and vertical lines represent median values of the centrality and clustering. Closeness values multiplied by 100.

Summary

This analysis explored the structure and relationships of reasons for playing games by modeling the RPVG-46 as a network in which items are represented as nodes and partial correlations between items as weighted connecting the nodes. Techniques from graph theory including centrality and clustering coefficient were used to assess the relative importance of individual nodes and demonstrated the central role of the item "I play games when I'm feeling stressed." The patterns association between nodes suggest that gamers who play for immersion in a world or story are less interested in competition and skill development. When they do play for stress relief, it is for the escape provided by feeling like they are somewhere else for a while.

Analysis 2: RPVG-32

The objective of this analysis was to investigate whether nodes associated with stress relief were high in centrality in the RPVG-32 sample described in Chapter 5, Study 3. In this version of the RPVG, only items without significant cross-loading were retained, so the item "I play games when I'm feeling stressed" which played such a central role in the network of the RPVG-46 (described in Analysis 1, above) will not be present in this analysis. If stress relief indeed plays a central role in gaming motivations, items such as "to reduce stress by working out aggression" and "to reduce stress by relaxing" should be more prominent in the network than items like "for a challenge" or "to play with friends".

The RPVG-32 study included preferred console, gameplay frequency and genre preference (see Ch. 5, Study 3), so a secondary objective of this analysis was to investigate the effects of including genre in the partial correlation matrix. I expect that certain genres are associated with specific reasons for playing games; for instance, gamers who play to be part of an online community would be very likely to play massively multiplayer online games (such as World of Warcraft), so these nodes should be closely linked in the network. Including genre in the network also provides the opportunity to investigate the possibility that clusters of reasons for playing games are effects of being associated with a particular genre. It may be that nodes of the "Adventure" cluster, which include playing to experience the world of the game, the story of the game, to explore somewhere new, and to have an adventure, are clustered because they are all characteristics of roleplaying games like Skyrim.

Network Analysis

The network analysis of the RPVG-46 described in Analysis 1, above, used the `adalasso` command of the *qgraph* package, which unfortunately is very slow to run (Epskamp et al., 2012). A newer and much faster method is implemented in the `EBICglasso` command, which uses a different model selection procedure (directly penalising elements of the variance-covariance matrix rather than penalising regression coefficients (Meinshausen, Bühlmann, & others, 2006)) and is currently the recommended procedure for estimating psychometric network models (Costantini et al., 2017; Epskamp & Fried, 2018). I used both procedures to estimate the RPVG-46 and

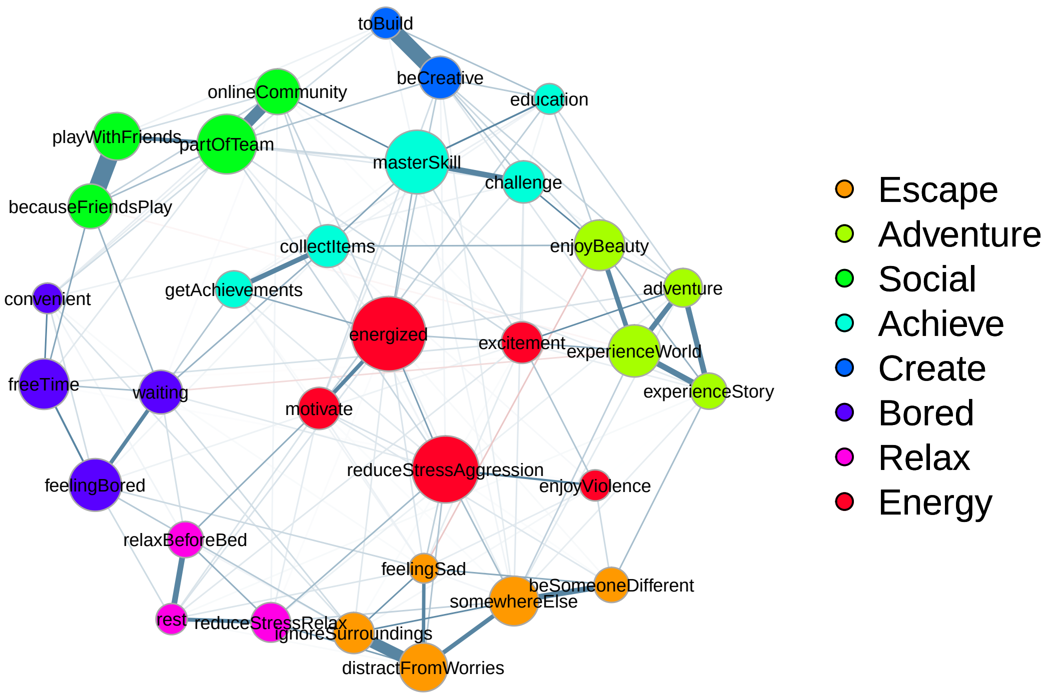

Figure 6.6: Network of RPVG-32, with node size scaled by Betweenness.

RPVG-32 networks and found no substantial differences between the EBICglasso and adalasso in the resulting network, so this and the following analysis will employ the EBICglasso.

RPVG items only

The network is plotted in Figure 6.6, with node size scaled by betweenness centrality.

The network, plotted in Figure 6.6, has 155 edges, 151 of which are positive (shown in blue) and 4 of which are negative (shown in red); the t-test indicates that this difference in edge weights between positive and negative edges is not significant, $t(155) = 1.3806$, $p = 0.17$. The weights of these four edges are all extremely close to 0 with the largest magnitude being -0.056 between “enjoy beauty” and “feeling sad”.

In general, the nodes appear to grouped by the factors they were designed to represent, with some more tightly clustered (Adventure, Relax) than others (Social, Achieve).

Centrality Stress relief still appears to play a central role in the network. The item “I play games to reduce stress by working out aggression” (‘reduceStressAggression’) is the second-highest node in Betweenness and Strength and the third-highest in Closeness. However, the node highest in centrality overall was “to feel energised”, as it links multiple factor groups and also has strong connections to nodes within its own factor (especially “motivate” and “reduceStressAggression”). Figure 6.7 shows the network with node size scaled by each of the three centrality measures.

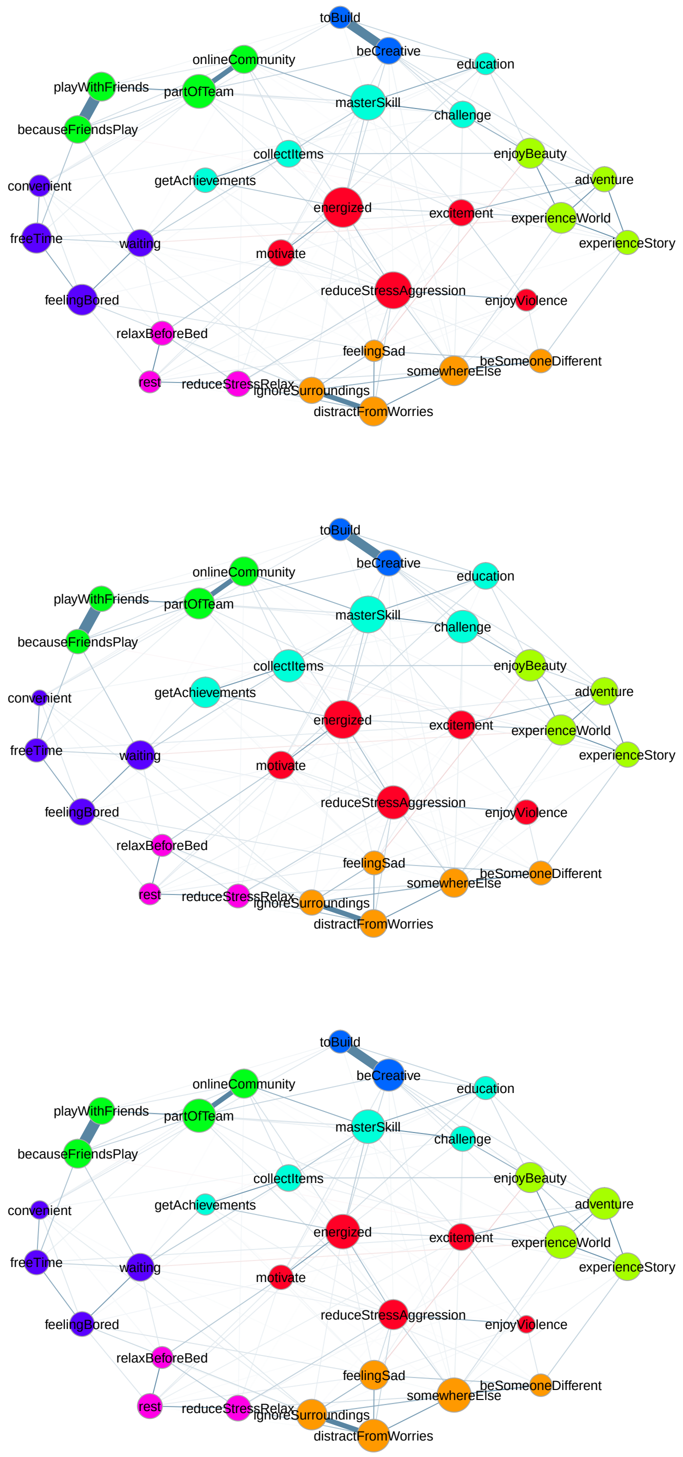

Figure 6.7: Node size scaled by betweenness (top), closeness (center) and strength (bottom).

Clustering Figure 6.8 plots clustering coefficient by centrality index. “Energized”, “masterSkill” and “reduceStressAggression” are consistently high in centrality but low in clustering, emphasising their importance in the network. “ExperienceStory” is likely redundant given the other nodes in the Adventure cluster, with a very high clustering coefficient. “EnjoyViolence” has a low clustering coefficient but also low centrality, indicating that it does not play an important role in the network.

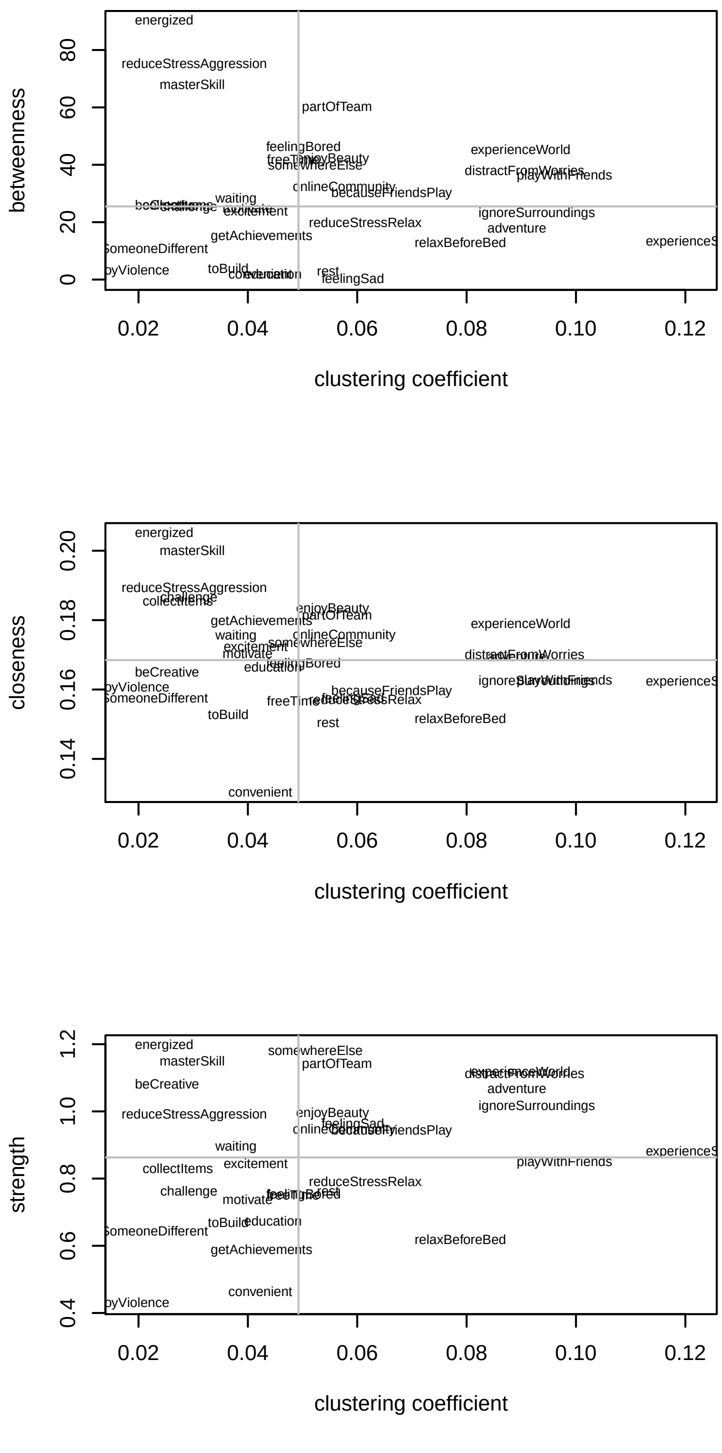

Figure 6.8: Centrality plotted by clustering coefficient. Horizontal and vertical lines represent median values of the centrality and clustering. Closeness values multiplied by 100.

RPVG and genre

The network plot in Figure 6.9 includes genre. Several genres are directly linked to reasons for playing games, while others are only directly linked with other genres. Massively multiplayer is linked with "to play with friends" and "to be part of an online community", with a weak link to the shooter genre. RPG (role-playing game) has direct links with "to experience the story of the game" and "to have an adventure" but also links with the genres of adventure with combat and also grand strategy. "I play games for education" has been a peripheral node in previous samples but here has a direct link with the puzzle and grand strategy genres, and the RPVG nodes "to master a skill", "to motivate me", and "to be creative".

Centrality As shown in Figure 6.10, centrality patterns remain fairly consistent across the three indices. "Energized" and "reduceStressAggression" remained the most central nodes. The "build" and "creative" nodes increased in centrality due to their links with the exploration, sandbox and simulation genres.

Clustering The racing and sports genres played the least important role in the network, with low centrality and low clustering coefficients. "Energized", "masterSkill", and "reduceStressAggression" remain important nodes (Figure 6.11).

Summary

Analysis 2 used the new EBICglasso procedure to estimate the network of reasons for playing games in the RPVG-32 sample described in Chapter 5, Study 3, which was developed from the RPVG-60 via principal components analysis and omission of items with significant cross-loading. The analysis found that the item "I play games to feel energized" was the most central, though stress relief still played an important role, with the item "I play games to reduce stress by working out aggression" also having high centrality. Additionally, some genres were closely associated with RPVG clusters: the roleplaying and adventure genres were linked with the Adventure cluster, and the massively multiplayer genre was linked with the Social cluster.

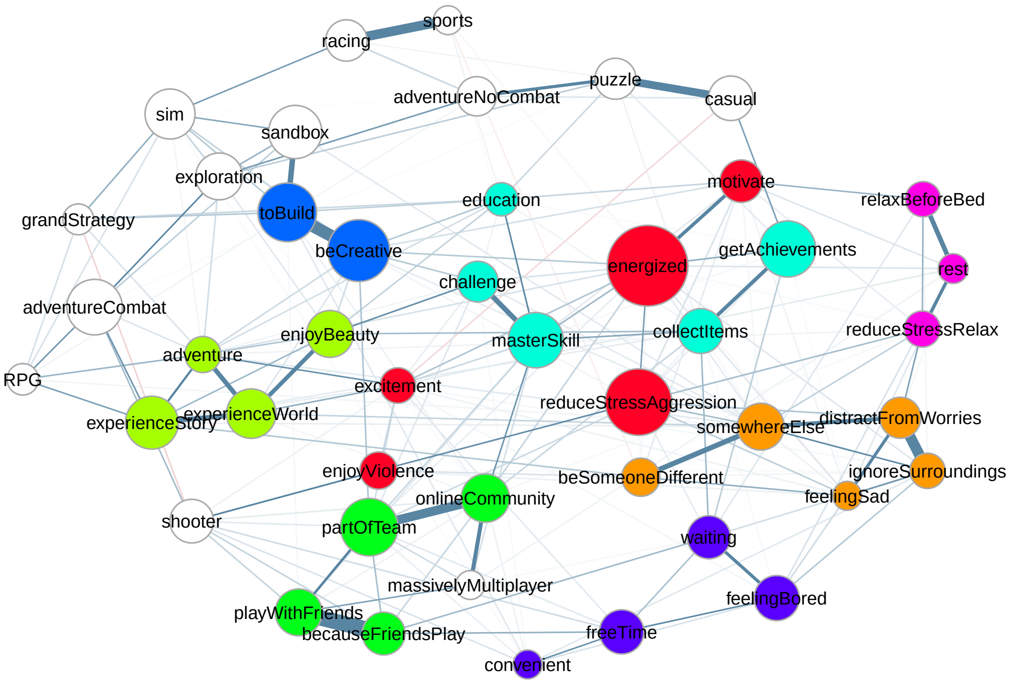

Figure 6.9: Network of RPVG and genre, with node size scaled by Betweenness.

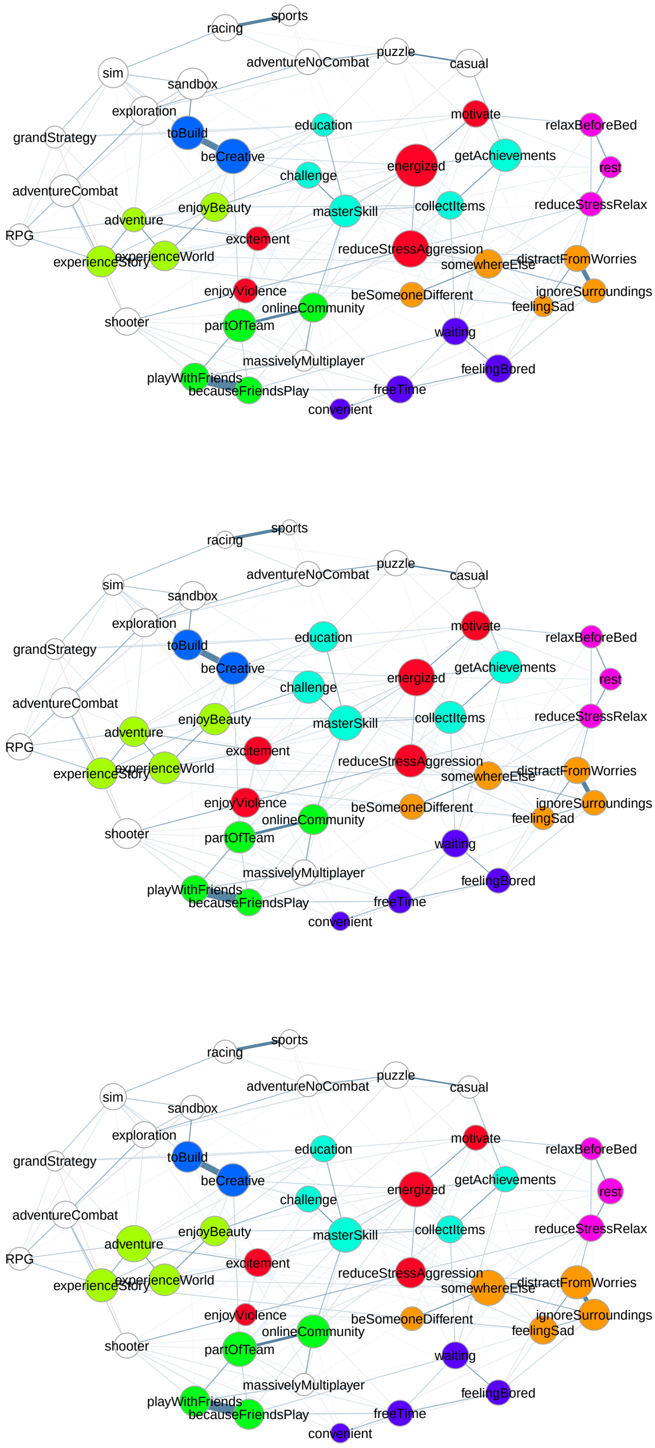

Figure 6.10: Node size scaled by betweenness (top), closeness (center) and strength (bottom).

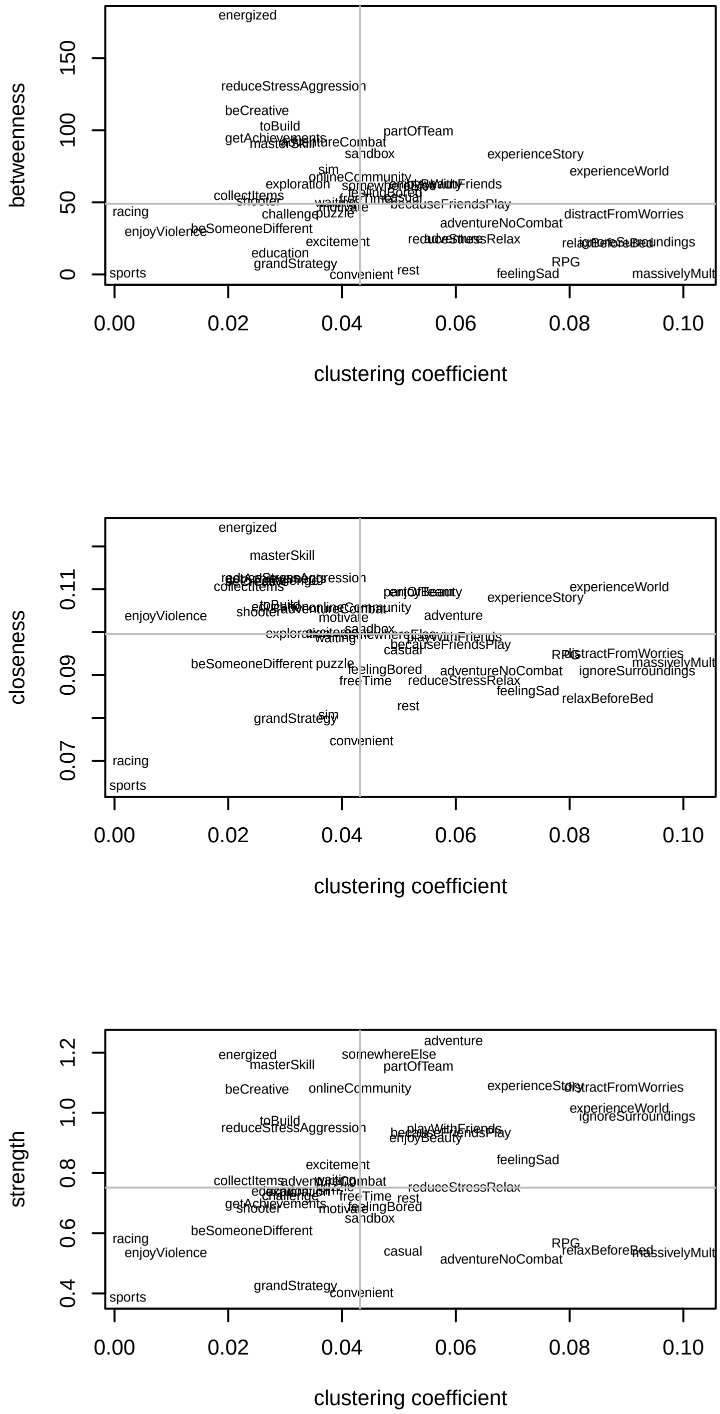

Figure 6.11: Centrality plotted by clustering coefficient. Horizontal and vertical lines represent median values of the centrality and clustering. Closeness values multiplied by 100.

Analysis 3: RPVG-23

As described in Chapter 4, the Reasons for Playing Video Games items employed in the EVS2 study were selected through a process of traditional variable reduction with principal components analysis. This approach sacrificed detail in favour of a smaller bank of items with a clearer factor structure, but the relationships between items are still interpretable as a network, albeit a less complete one than that described in the previous section.

Network Analysis

As with the RPVG-46, I computed the partial correlation matrix using the adaptive LASSO function from the *qgraph* package.

The network has 107 edges, 87 of which are positive and 20 of which are negative. Positive edges are associated with larger weights (M = .12, SD = .09) than the negative edges (M = .04, SD = .03), and the t-test indicates that this difference is significant, $t(105) = 3.81$, $p = 0.0002$.

As shown in the network plot in Figure 6.12, the Distract and Escape factors are intertwined, with the strongest link through "distract from worries." Figure 6.20 shows the shortest paths through the "stressed" node ("I play games when I'm feeling stressed"). There are direct links from "stressed" to "relax", "aggression", "break from work", "distract from worries", and "inspire", and all of these nodes provide links to the other factors.

Centrality

Figure 6.14 compares the three centrality measures with node size scaled by betweenness, closeness, and strength. Betweenness shows a slightly different pattern than closeness and strength, with "control" and "stressed" being the most central nodes.

Centrality values for each node are listed in Table 6.2.

Clustering

Figure 6.15 compares patterns of clustering coefficient by each centrality measure. "Creative" and "adventure" are consistently high in clustering, indicating possible redundancy in the network due to their strong correlations with other nodes. "Control", "stressed", and "ignore surroundings" are consistently high in centrality but low in clustering coefficient, further highlighting their importance in the network.

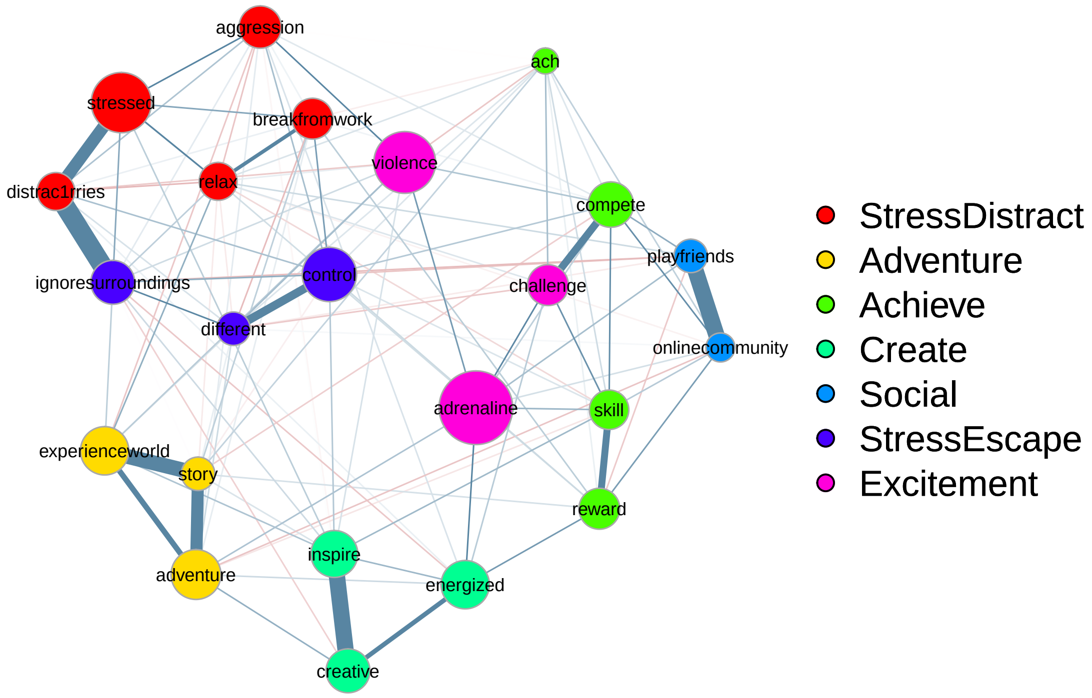

Figure 6.12: Network plot of RPVG-23.

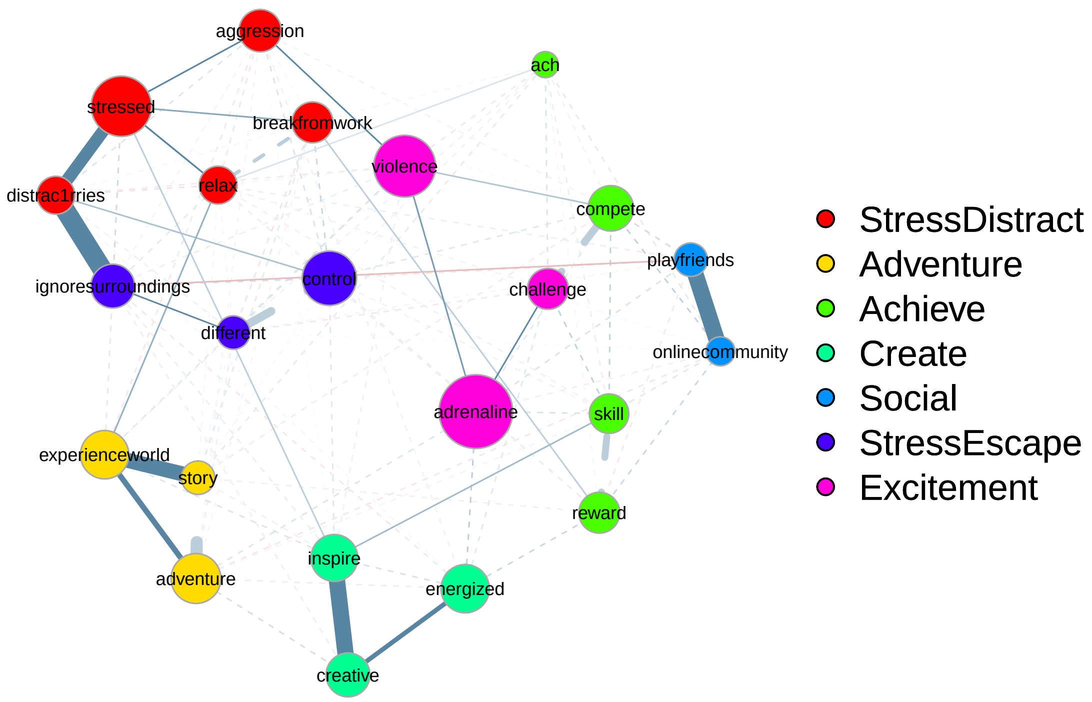

Figure 6.13: Shortest paths through node feelingStressed. Edges belonging to the shortest paths are solid, other edges are dashed.

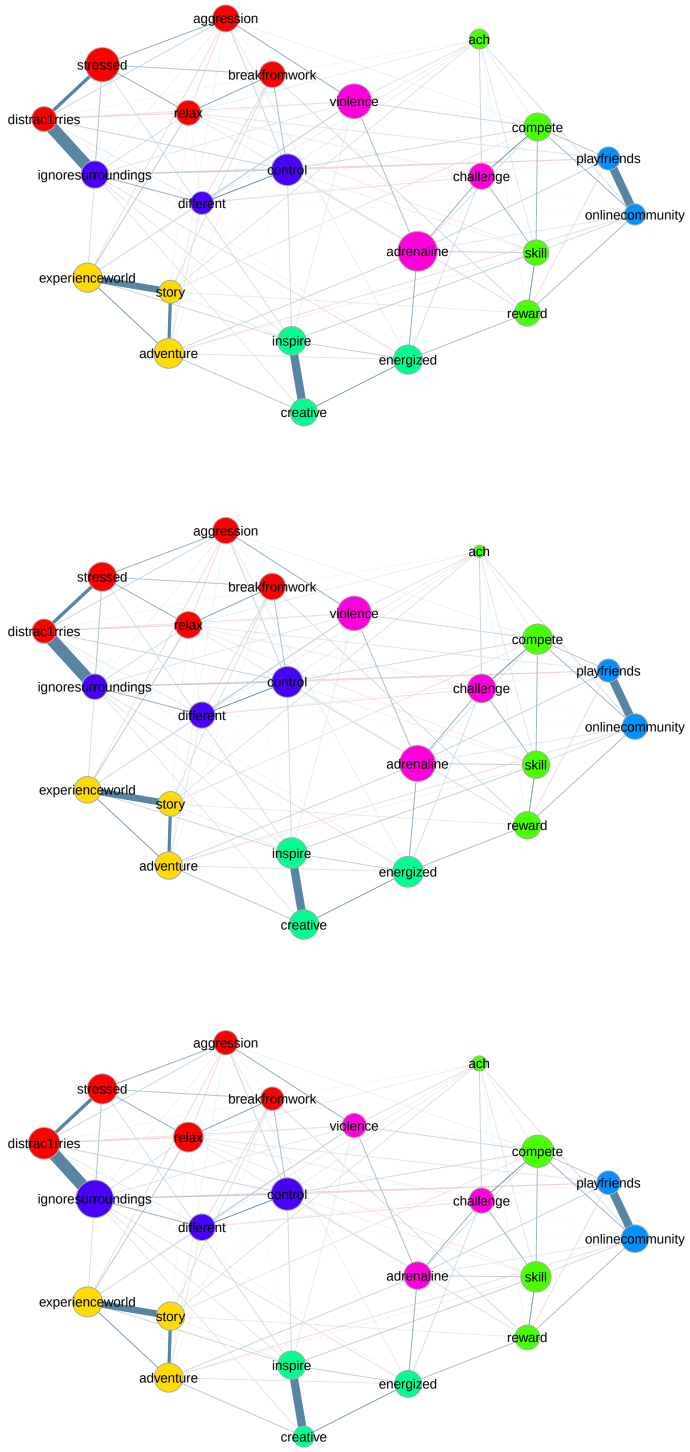

Figure 6.14: Node size scaled by betweenness (top), closeness (center) and strength (bottom).

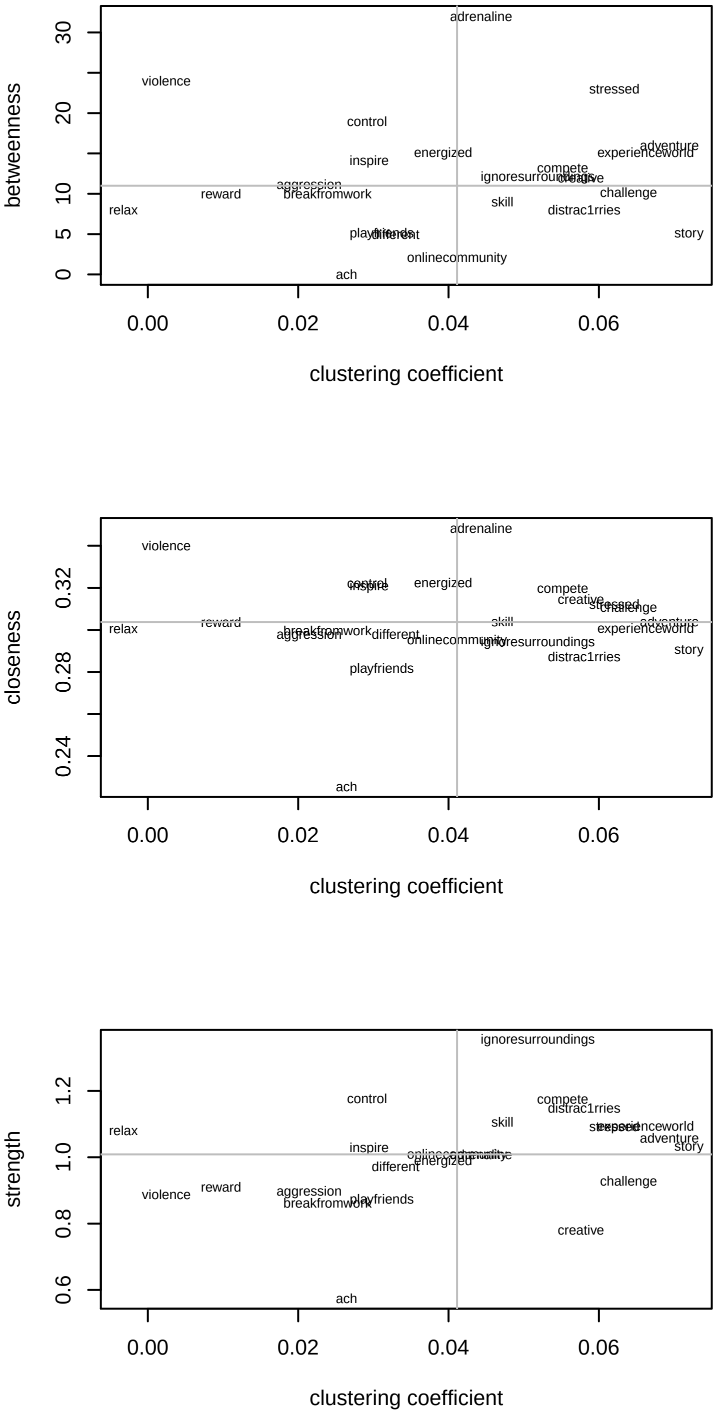

Figure 6.15: Centrality plotted by clustering coefficient. Horizontal and vertical lines represent median values of the centrality and clustering. Closeness values multiplied by 100.

Table 6.2: Centrality indices of Reasons for Playing Video Games, Study 3.

Node	Variable	Factor	Betweenness	Closeness	Strength
18	stressed	Distract	**23**	**3.12**	1.08
5	distractWorries	Distract	13	3.07	**1.22**
2	aggression	Distract	8	3.00	0.86
13	breakFromWork	Distract	12	3.04	0.87
23	relax	Distract	6	2.80	0.75
14	control	Escape	**25**	**3.48**	1.20
16	different	Escape	13	3.37	1.05
22	ignoreSurroundings	Escape	16	3.30	**1.31**
1	adventure	Adventure	12	2.97	1.00
12	story	Adventure	5	2.87	0.97
21	experienceWorld	Adventure	**18**	**2.99**	**1.16**
4	energized	Create	**16**	**3.31**	**1.06**
19	inspire	Create	15	3.19	0.97
3	creative	Create	9	3.06	0.72
7	adrenaline	Fight	**16**	**3.36**	**1.11**
20	violence	Fight	14	3.24	0.82
8	challenge	Fight	8	3.20	0.95
10	reward	Achieve	**14**	**3.16**	0.88
11	skill	Achieve	12	3.06	1.06
15	compete	Achieve	5	3.07	**1.14**
17	achieve	Achieve	0	2.53	0.60
9	community	Social	**8**	2.76	**0.96**
6	playFriends	Social	5	**2.81**	0.81

Accuracy and Stability of the Estimation

I investigated the stability of the three centrality indices (strength, betweenness, and closeness) with the case-dropping bootstrap in the *bootnet* package. Figure 6.18 shows that the stability of betweenness drops off more rapidly than strength and closeness, with strength remaining most stable as more cases are dropped.

Epskamp et al. (2018) introduce the *correlation stability coefficient* as a quantitative metric of stability which identifies "the maximum proportion of cases that can be dropped to retain, with 95% certainty, a correlation with the original centrality of higher than (by default) 0.7" (p. 15). My analysis of 1000 bootstraps indicates that strength (CS(cor = 0.7) = 0.75) and closeness (CS(cor = 0.7) = 0.517) exceed the cutoff of 0.5 identified in simulation studies by Epskamp et. al required to consider the index to be stable, while betweenness does not (CS(cor = 0.7) = 0.128).

Figure 6.16 shows the bootstrapped confidence intervals of the estimated edge weights in the network, with each horizontal line representing one edge in the network, ordered from highest weight at the top to lowest weight at the bottom. The many overlapping confidence intervals indicate that most of the edge weights do not significantly differ from each other, though there are several reliably strong edges.

Statistical significance of node strength is shown in Figure 6.17. "Achieve" had the lowest node strength and was the only node to be significantly different from all other nodes.

As Epskamp et al. (2018) has pointed out, network psychometrics is still in its infancy and precise power calculations have not yet been developed. Epskamp's simulation studies indicate that larger sample sizes yield more accurate estimation, but at the moment we are limited to post-hoc significance and stability testing.

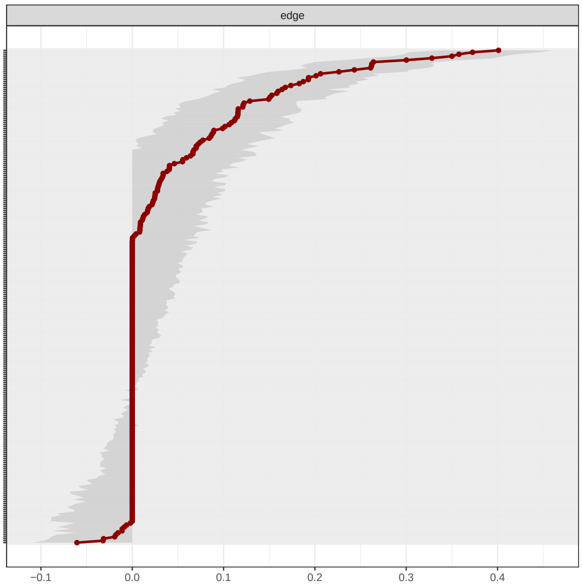

Figure 6.16: Bootstrapped confidence intervals of estimated edge weights. The red line indicates sample edge weight value and the gray area represents the bootstrapped confidence interval.

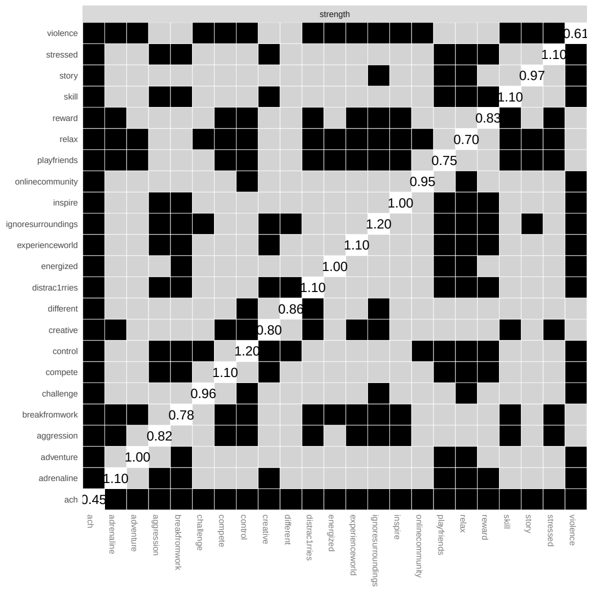

Figure 6.17: Bootstrapped difference tests of node strength. Gray boxes indicate nodes that do not differ significantly from each other, and black boxes indicate nodes that do differ significantly. Value of node strength for each variable is shown on the diagonal.

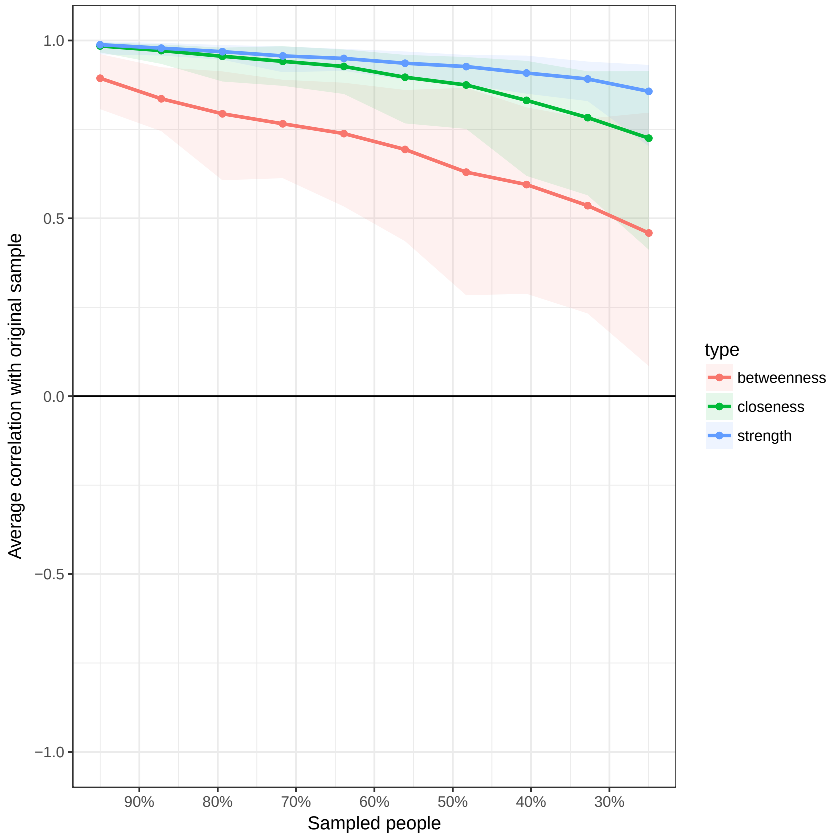

Figure 6.18: Average correlations between centrality indices of networks sampled with cases dropped and the original sample, with shaded areas indicating the 2.5th to 97.5th quantile.

The Big Picture

We can begin to see the bigger picture of gameplay motivations and style by including more nodes in the system, allowing us to probe the relationships with personality and perceived stress in a holistic, exploratory manner. Figure 6.19 depicts the network of the EVS2 study, which had the largest sample size (N = 961) and the most comprehensive measures of stress, personality, genre, gameplay style and motivation, and provides an opportunity to explore the "big picture" of the data.

Note that because the adaptive LASSO estimation prioritises sparsity (Krämer, Schäfer, & Boulesteix, 2009), the absence of an edge in the network does not necessarily mean that two nodes are independent. However, we can be relatively confident that the presence of an edge indicates a relationship between two nodes in the data that cannot be explained by any other node in the network. This of course does not take into account the possibility of influential variables which have not been included in the network.

Genre

The relationships between genre preference and RPVG are consistent with those seen in Study 2 of this chapter, which explored the relationships between the RPVG-32 items and genre. Given that the RPVG-32 and RPVG-23 were developed in different ways, this consistency is encouraging. Most of the genres are not strongly related to style or reasons for playing and appear as a relatively isolated group in the network. However, the massively multiplayer genre is clearly situated within the social gameplay cluster which includes both the social style and motivations nodes. The shooter genre is similarly connected more with the style and RPVG nodes than with other genres, but unlike massively multiplayer it links several clusters and is higher in Betweenness centrality (with a value of 51) than massively multiplayer (with a value of 4). These are broad genres encompassing many different types of games, which likely contributes to their higher correlation with the RPVG and style factors, but they may also be more suited to fulfilling specific needs.

As expected, the roleplaying and adventure with combat genres are clustered with the "adventure" RPVG cluster which consists of "to have an adventure", "to experience the story of the game" and "to experience the world of the game". The "adventure without combat" genre behaves differently, being more closely linked with the puzzle and exploration genres and the story, achievement and inspiration RPVG nodes and unsurprisingly negatively associated with "because I enjoy the violence."

Personality

Personality did not play a strong role in the network, though Openness to experience was associated with playing games to be creative, as shown in Figure 6.19. The links between Neuroticism and stress have been well-documented in the literature (Bolger & Schilling, 1991; David & Suls, 1999; Penley & Tomaka, 2002), and Neuroticism's high correlation with perceived stress score did link it with the distraction/escapism/stress relief cluster.

Pathways of the Stress Recovery Experience

Figure 6.20 shows only the shortest paths through the RPVG node "stressed" ("I play games when I'm feeling stressed"). In general, the influence of the "stressed" node propogates to specific genres via other RPVG nodes and gameplay style factors. These pathways suggest possible causal relationships and are consistent with Sonnentag's four-dimensional Recovery Experience construct (Sonnentag et al., 2008; Sonnentag & Fritz, 2007). The recovery experience involves psychological detachment, relaxation, mastery experience and control. Psychological detachment can be seen in the network as the pathway from "distract from worries" through "ignore surroundings" and "(be someone) different (from who I am in real life)", to the Immersion gameplay style factor, and finally to the genres of adventure and roleplaying. The relaxation element of the Recovery Experience model appears in the network as the pathway from "stressed" to "relax", to the adventure cluster of "experience world", "story" and "adventure", and again to the roleplaying and adventure genres.

The control element of recovery experience manifests as the "control" node ("I play games to feel in control"), which was also the most central node in the RPVG-32 (which omitted the stress relief node). The control pathway branches at the "inspire" node, with one branch connecting through creativity to the puzzle, sandbox and simulation genres and the other branch passing through "energized" and "adrenaline" to the challenge node, which in turn branches locally to the achievement and socialising clusters. Mastery experience is the only facet not directly

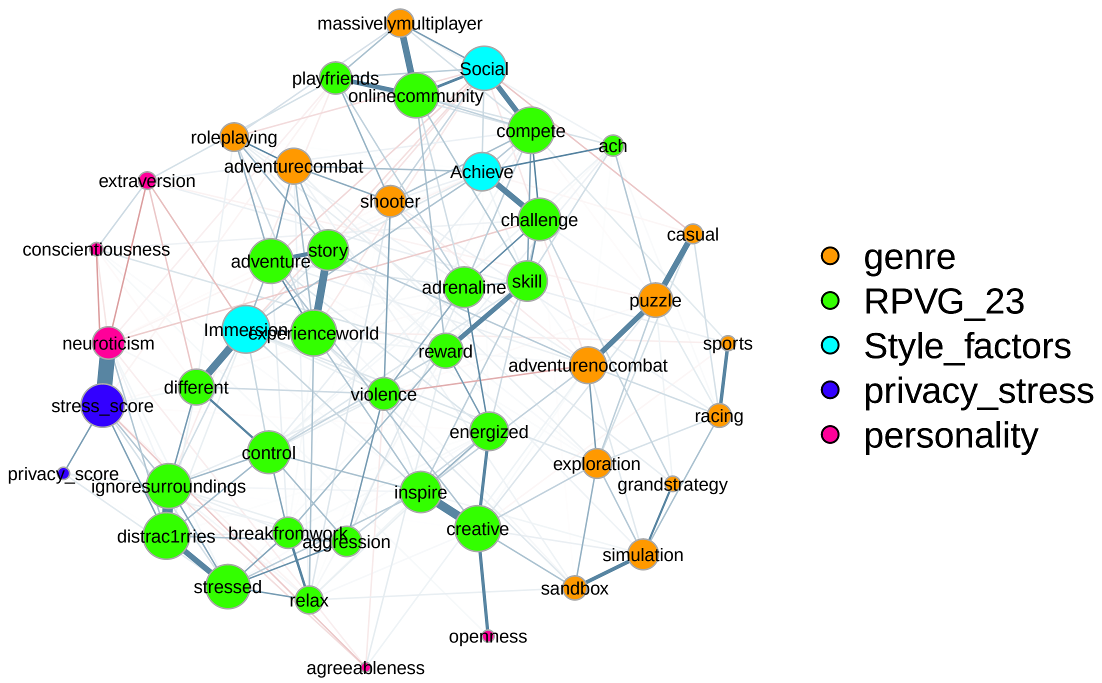

Figure 6.19: Network showing partial correlations of genre, RPVG-23 items, style factors, perceived stress and privacy, and Big Five personality scores. Node size is scaled by Strength.

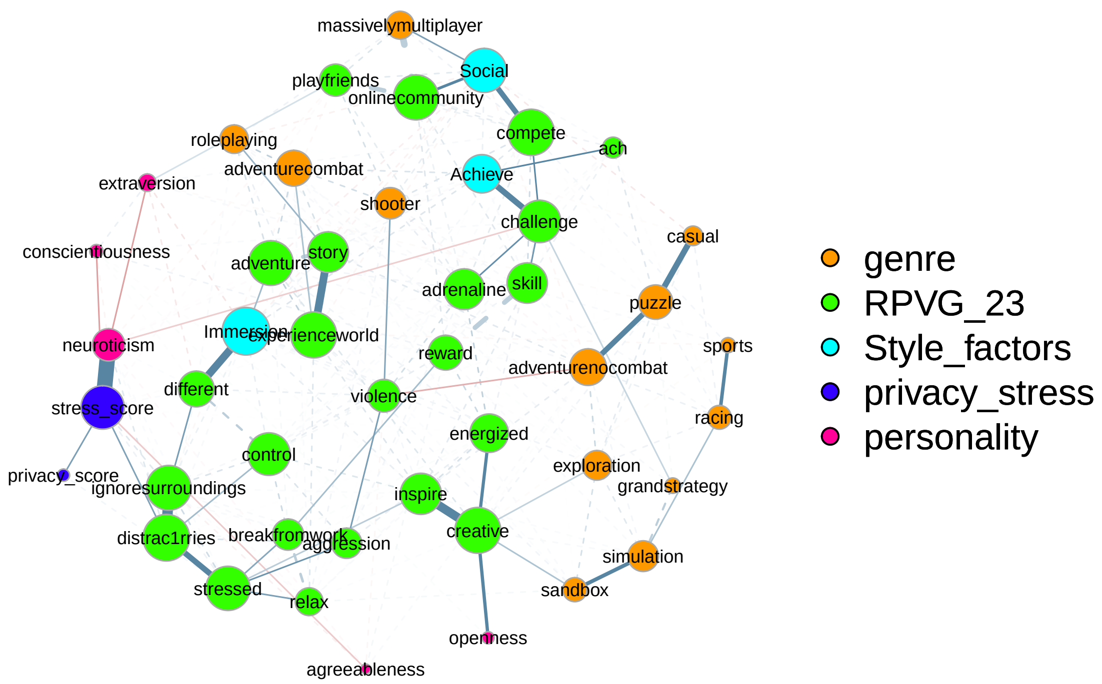

Figure 6.20: Shortest paths through node feelingStressed. Edges belonging to the shortest paths are solid, other edges are dashed.

represented by a node, though it is present in the network through the nodes of "break from work", "(as a) reward (for doing something productive)" to "skill", and through the "(to work out) aggression" and "(because I enjoy the) violence" nodes.

CHAPTER 7

DISCUSSION AND FUTURE DIRECTIONS

Key Findings

The three-factor structure of gameplay style

The empirical studies in this dissertation provide strong support for a three-factor struture of gameplay style. These factors of Immersion, Socialising and Achievement are orthogonal[1] and represent distinct and recognisable approaches to playing games. They are not artefacts of genre differences, though preference for a particular gameplay style may be associated with preference for a particular genre, with Immersion-focused gamers tending to prefer roleplaying, exploration, sandbox and adventure games, Social gamers preferring massively multiplayer and shooter games, and Achievement gamers preferring combat and strategy games. Gameplay style is correlated with personality: Achievement-oriented gamers tended to be higher in Conscientiousness and lower in Neuroticism, Social gamers higher in Extraversion, and Immersion gamers higher in Neuroticism and lower in Extraversion. Gamers with an Immersion play style tended to play for escapism, distraction, and fantasy/adventure, while social gamers played for excitement, energy and self-expression. Achievement-oriented gamers played to have a challenge and were less likely than social and immersion-focused gamers to play for distraction and escapism.

For the sample of gamers with an autism spectrum condition, the gameplay style factors were not orthogonal. The Immersion and Achievement factors were correlated with each other and both were associated with playing to relieve stress, distract from worries, and escape from real life, though only Immersion was related to playing for relaxation, suggesting that autistic gamers may feel more engaged by the logic and strategy that characterises an Achievement play style. Autistic gamers hardly ever reported playing to socialise (with children being more likely to do so than adults).

[1] except, interestingly, among gamers with autism, see following paragraph

Gaming for stress relief versus gaming for fun

In general, gamers experiencing more stress in their daily lives were more likely to have Immersion-focused rather than Social or Achievement-focused play styles. While Immersion was correlated with most of the gaming motivations factors, stressed gamers were more likely to play explicitly for distraction or escape rather than to have an adventure.

In a hierarchical factor model of reasons for playing games, the two higher-order factors seem to express the difference between gaming for stress relief and gaming for fun. The first factor had high loadings from the Distract and Escape factors, while the second had loadings from the Achieve, Social and Excite factors. Network analysis of the Reasons for Playing Games items suggests that gamers who play for immersion in a world or story are less likely to play for competition and skill development.

Parallels with music and mood management

Though the factor models of reasons for playing games suffered from inconsistency, it is interesting to note some parallels with the use of music for mood management and stress relief. Emotion regulation has been shown to be one of the most important motivations for listening to music (DeNora, 2000; Juslin & Laukka, 2004). Saarikallio & Erkkilä (2007) identified seven regulatory strategies involving musical activities: entertainment (e.g. listening to music to maintain a positive mood or to evoke positive emotions), revival (e.g. listening to music to relax or to get energized), strong sensation (e.g. listening to music to experience intense feelings of pleasure), diversion (e.g. listening to music to forget about something undesirable), discharge (e.g. listening to music to release anger), mental work (e.g. listening to music to get inspired and get new ideas), and solace (e.g. listening to music to get some comfort). These regulatory strategies have clear parallels in the factor models of reasons for playing games: “revival” and “strong sensation” map onto the Relax and Energise factors, “diversion” maps onto the Escape and Distract factors, “discharge” maps onto the Catharsis factor, and “mental work” maps onto the Create factor. The gaming motivations factors which do not have parallels in music listening motivations are Adventure and Achievement, i.e. those reasons for playing that are interactive. More parallels appear when one considers music *performance*, where skill development and mastery of an instrument map clearly onto Achievement.

Mapping of stress recovery experience onto reasons for playing games

The elements of Sonnentag’s Recovery Experience construct of psychological detachment, relaxation, control and mastery (Sonnentag et al., 2008; Sonnentag & Fritz, 2007) can all be fulfilled by video game playing. Gamers who play when they are feeling stressed may play for psychological detachment by distracting themselves from worries, ignoring their surroundings, and playing to be someone different from who they are in real life. Gaming can provide relaxation, especially for gamers who play to experience the world or story of a game. The interactivity of video games makes them an ideal way to feel more in control, and was the most central node in the version of the RPVG that omitted the “I play games when I’m feeling stressed”. Finally, games contain many opportunities for mastery as players reach new high scores, learn the intricacies of the gameplay mechanic, solve puzzles, improve their aim, and many other experiences. The intelligently scaled difficulty system of many modern games means that the game becomes more challenging as the player progresses, a hallmark of the Flow experience (Csikszentmihalyi, 1999).

Limitations

Early focus on factor models shaped RPVG development

I stated in the overview of the literature in Chapter 1 that previous factor models of gaming motivations have suffered from inconsistency. My own initial efforts came from a factor-analytic perspective, and I encountered the same pitfalls of over-simplification, variable selection based on cut-offs, and inconsistent factor models. This struggle eventually led me to consider network psychometrics, which I now believe to be a much more elegant approach. However, the struggle is evident in the rather tangled history of the Reasons for Playing Video Games, which has not yet developed into the robust psychometric tool I had hoped it would.

Limited generalisability

The use of an interactive "personality quiz"-type online questionnaire allowed me to obtain a relatively large number of participants (over 2,000 across all studies), but this sample is certainly biased. Online recruitment via social media such as gaming forums will have over-represented participants who consider themselves "gamers" and under-represented players of casual games. Though the Steam web API provided useful objective data such as validation of the measures of gameplay time and preferred genre, it also biased our sample toward PC gamers, under-representing the population of gamers who use consoles such as PlayStation or Xbox.

Risk of over-interpretation of networks

As discussed in the previous chapter, network analysis is a relatively new technique without established norms for sample size and network stability. Networks of even the largest of my samples, with 981 participants, showed some instability in measures of centrality. Additionally, the absence of an edge in the network does not necessarily mean that two nodes are independent, and there is also the possibility of influential variables which may not have been included in the network. Finally, the empirical studies in this dissertation were cross-sectional and correlational, though partial correlations can suggest causal relationships (Epskamp & Fried, 2018). The network analyses in Chapter 6 should therefore be seen as *hypothesis-generating* for future experimental and longitudinal studies.

Future Directions

Exploring the causal link between gaming and stress relief

This dissertation illustrates a link between immersion and gaming for stress relief and suggests that gamers who experience more stress are more likely to play open-world games like Skyrim. However, we will need to move beyond cross-sectional research to investigate the causal hypotheses generated by this work and assess any benefit or harm from using video games to relieve stress. In the next part of this chapter, I will describe several studies which were planned but could not be completed due to funding or time constraints during the course of this PhD. I will also summarise the qualitative portion of the Minecraft and Autism study which was presented in Chapter 4, and will conclude by considering some of the recent advances in applying network psychometrics to longitudinal data.

Game mode and acute stress recovery

In order to investigate whether the link between stress and gaming is causal, an experimental study of stress induction and recovery could be performed. Similarly to Annerstedt et al. (2013), who investigated the use of a virtual reality natural environment (a forest scene) in stress recovery, one could induce stress reactions in a laboratory and measure psychological and physiological recovery. Various recovery conditions could be examined: for example, an open-world naturalistic game environment, an open-world urban game environment, a puzzle game, an action-based game, or a control condition not involving a video game. To explore the association between open-world games and playing for stress relief, it would be interesting to see whether the exploration conditions best facilitate stress recovery, and whether the naturalistic environment relieves stress more effectively than the urban environment.

The study design could draw on that of Annerstedt et al. (2013), with the main difference being a replacement of their CAVE automatic virtual environment (a virtual reality system involving projecting images onto the walls, floor, and ceiling of a room) with simple computer game conditions, all created within Minecraft.

Given the availability of different game modes within Minecraft, it is possible to create various experimental conditions using the same game. An exciting new tool available to researchers is HeapCraft (www.heapcraft.net), a Minecraft plugin developed by Stephan Mueller which collects specific gameplay information such as player movement and interaction within the game; for some example visualisations, see Figure 7.1.

Tools like Heapcraft can allow researchers to study gaming behaviour “in the wild,” no longer forced to rely on self report to assess gameplay preferences and style. Additionally, the ability to make associations between psychological constructs and specific gameplay behaviours show promise for Minecraft as a virtual laboratory environment.

After inducing stress via the Trier Social Stress Test (Kirschbaum, Pirke, & Hellhammer, 1993) (again, utilising the same design as Annerstedt et al.) we would randomly assign participants to one of four recovery conditions or one control condition involving recovery in a quiet room

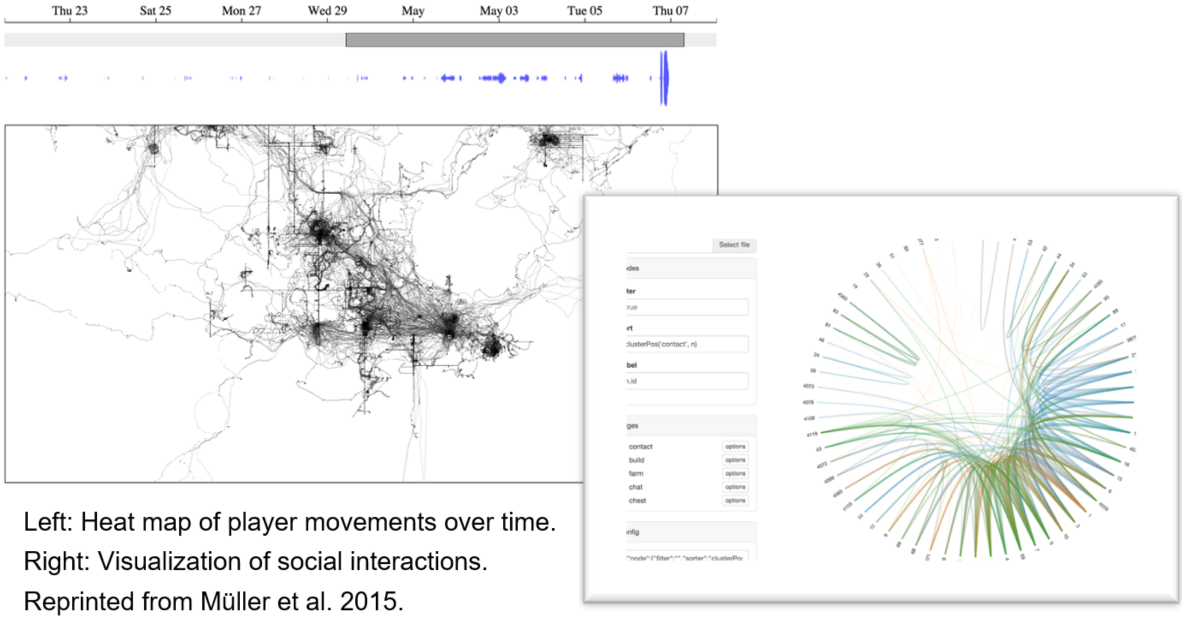

Figure 7.1: Example data visualisations in HeapCraft

with no video game or natural environment stimulus. The four recovery conditions can all be administered within Minecraft: 1) a peaceful natural environment which the participant can explore, 2) an urban cityscape environment which the participant can explore, 3) a combat-based challenge in which the participant must fight aggressive monsters, and 4) an abstract puzzle in the form of a maze which the participant must escape. In addition to psychometric measures of stress and anxiety, physiological measures of stress such as salivary cortisol, ECG and respiration, and heart rate variability could also be administered to compare stress recovery in each of the conditions.

Gaming as a stress intervention: a proposed randomised controlled trial

In collaboration with Dr. Matt Bristow and the Biomarker Analysis Laboratory at Anglia Ruskin University, I designed a parallel randomised controlled trial of the effect of Minecraft gaming on stress and mood over a six-week period. A sample of 80 undergraduates would be randomly assigned either to play Minecraft or to watch videos of nature scenes during their typically stressful exam term. In addition to traditional questionnaire measures of wellbeing and stress, hair cortisol level could be measured pre- and post- intervention for both groups. While I was not able to complete this study due to funding limitations, the design and research protocol were finalised and are described here.

Background

The mental health of university students is a growing concern both in the UK and the United States. A 2015 study revealed that 78% of students have experienced mental health problem, and over 30% have considered self-harm.[2] At the University of Cambridge, demand for counselling

[2] https://www.varsity.co.uk/news/9450

services has doubled in the past five years,[3] and many students turn to self-medication, particularly with alcohol, to see them through periods of extremely high stress and anxiety.

Among the healthier coping strategies students employ is playing video games. To our knowledge all experimental studies of video games and stress relief have investigated acute rather than long-term stress. Similarly, experimental studies of virtual natural spaces have employed acute stress induction and salivary cortisol or other acute physiological measures (Russoniello et al. (2009); Kort et al. (2006); Annerstedt et al. (2013)). However, many students report playing games for relief from chronic school-related stress. Given recent advances in hair cortisol analysis, it is now possible to employ a retrospective psychophysiological measure of stress (Gow, Thomson, Rieder, Van Uum, & Koren, 2010; Russell, Koren, Rieder, & Van Uum, 2012). Hair cortisol is a relatively new measure which has shown strong validity in clinical populations but needs further validation with healthy populations (Staufenbiel, Penninx, Spijker, Elzinga, & Rossum, 2013), therefore we would be combining hair cortisol analysis with traditional questionnaire assessments. The availability of a typically-stressed population of Cambridge undergraduates obviates the need for artificial stress induction. Our study would use an active control condition (viewing films of natural environments), which has been established to improve directed-attention abilities (Berman, Jonides, & Kaplan, 2008) and decrease stress (Annerstedt et al., 2013; Kort et al., 2006).

Procedure

After completing the screening process and providing written consent, baseline stress and mood would be assessed. A sample of approximately 50mg of hair would be cut from the vertex posterior of the head and stored securely at the Biomarker Analysis Laboratory at Anglia Ruskin University for cortisol analysis. Participants would then complete several measures of video game experience, gameplay style, and typical reasons for playing games.

Participants would be randomly assigned to two conditions. Participants in the experimental condition would play Minecraft on our server running the HeapCraft plugin, from their home computer in one 30-minute session per day, 4 days per week, for 8 weeks. Participants in the control condition would watch relaxing films of natural environments on the same schedule as the Minecraft condition. An example of a nature film can be seen here: https://www.youtube.com/watch?v=Kb8CW3axqRE. Both groups would complete mood and stress questionnaires every two weeks (at week 2, 4, and 6). Additionally, we would make contact by telephone with each participant during week 4 of the experiment to confirm that there is no interference with students' academic performance or undetected negative effects on mood or wellbeing. After the 6-week intervention period, we would collect a second hair sample for cortisol. One month after the conclusion of the study, we would re-administer the mood and stress measures to investigate any lasting effects.

Self-reported stress and mood would be assessed via the Perceived Stress Scale (PSS-10), the Positive and Negative Affect Scales (PANAS), and the Depression Anxiety Stress Scales (DASS-21). We would also administer the 10-item Big Five Inventory of personality, the Reasons for Playing Video Games questionnaire (RPVG-46), and a measure of previous gaming experience.

[3] http://www.tcs.cam.ac.uk/news/0035794-demand-for-university-mental-health-services-doubles.html

We would use an enzyme-linked immunosorbent assay (ELISA) to analyze the concentration of cortisol in participants' pre- and post- intervention hair samples.

Longitudinal network analysis

Experimental studies such as those described above would help determine the existence of a causal link between gaming and stress relief. For a more detailed exploration of the effects of gaming on stress, however, we can employ longitudinal techniques such as the Experience Sampling Method, in which participants are asked at intervals to report their mood, situation, or other information of interest, often via a smartphone app (Csikszentmihalyi & Larson, 2014). The resulting time series data can be modeled with a powerful new development to network psychometrics: longitudinal networks (Bringmann et al., 2013; Leemput et al., 2014).

In a network perspective of psychopathology, mental disorders such as depression can be understood as networks of interacting symptoms that form mechanistic property clusters: sets of causally intertwined properties that need not share one fundamental underlying cause (Borsboom, 2008; Borsboom & Cramer, 2013; Bringmann et al., 2015). Such dynamic networks of symptoms can be modeled with “a multilevel approach to vector autoregressive (VAR) modeling that optimally utilizes the nested structure that typically arises in ESM protocols”, which allows for modeling at both the individual and population level (Bringmann et al., 2013). In their 2015 study of depressive symptoms, Bringmann et al. demonstrated this technique in two examples. The first investigated the effects of an explanatory “therapy-intervention” variable on networks of symptoms at the individual level. The second explained variability in individual networks due to covariates such as neuroticism, exploring whether the structure of the network (measured by centrality) changes when the degree of neuroticism changes.

I will conclude by discussing two possible applications of longitudinal network analysis to the study of video gaming and stress relief.

Comparing the stress-buffering effects of physical exercise with video games

Since Morgan (1969)'s demonstration that physically unfit psychiatric patients were more depressed than their fit counterparts, researchers have continued to demonstrate the mental health benefits of physical exercise, and it is an oft-recommended treatment for those with clinical and subclinical depression (Dunn, Trivedi, Kampert, Clark, & Chambliss, 2005; Kvam, Kleppe, Nordhus, & Hovland, 2016) and anxiety (Carek, Laibstain, & Carek, 2011; Ströhle, 2009). Physical exercise, defined as a regular, structured, leisure-time pursuit (distinguishing it from domestic or occupational physical labour) provides opportunities for increased social activity (especially in competitive or team sports), skill mastery, and distraction. As Salmon (2001) has observed, the stress-relieving properties of exercise are not simply due to a hedonic effect; indeed, competitive or strenuous exercise is often associated with negative mood, especially among non-habitual exercisers (Clingman & Hilliard, 1994; Steptoe, Kimbell, & Basford, 1998; Yeung, 1996). Over a longer period of training, however, physical exercise is associated with reduced stress responses, which may be due to a process of “toughening-up” or increased resilience (see Salmon, 2001). The challenge and mastery experience of extended exercise training seems to have both psychological and physiological stress-buffering effects, suggested by Salmon to be linked to “adaptive changes in opioid systems, particularly those controlled by noradrenergic systems” (p. 50). Linking back to Sonnentag’s Stress Recovery Experience model, we can think of the detachment and relaxation components as taking the load off the system, and the control and mastery components as bolstering the system against future strain.

Many popular games are demanding, even stressful. First-person shooters and military simulators put players in realistic combat situations, and while playing “for the adrenaline rush” is a common reason for playing games, this comes with frustration and sometimes negative mood while playing (as mentioned in the RPVG open-response study Chapter 5). Future research could examine whether challenging experiences in video games have a similar stress-buffering effect, and what, if any, adaptive physiological changes occur as a result of playing such games. Longitudinal networks could allow for the modeling of rich Experience Sampling data, perhaps exploring the effects of playing games on the structure or stability of a network of reported stress-response.

Minecraft and Autism: predicting excessive engagement

As discussed in Chapter 4, there has been considerable anecdotal and some empirical evidence that video games are especially appealing to individuals with an Autism Spectrum Condition (Marzurek & Wenstrup, 2013; Mazurek et al., 2015; Mazurek, Shattuck, Wagner, & Cooper, 2012). In particular, parents have reported the positive impact of Minecraft on their child. Author Keith Stuart’s debut novel “A Boy Made of Blocks” (2016) was inspired by Minecraft’s positive impact on his real-life relationship with his autistic son.[4]

My 2016 mixed-methods study of gaming among autistic adults and children, described briefly in Chapter 4, had a substantial qualitative component in which I used grounded theory (Charmaz, 2006; Flick, 2007; Friese, 2014) to explore the perceived positive and negative effects of gaming in general and Minecraft in particular. One of the most common positive effects reported was stress relief. Autistic gamers reported that gaming provides a safe environment in which they feel in control. Other positive effects included skill development such as improved task switching and impulse control, positive peer relationships, improved self-esteem, and improved family/parent relationships.

Participants reported negative effects of gaming as well, however. Parents reported some mood and social problems associated with their child’s gaming, such as frustration when interrupted, and also cite concerns of bullying and being bullied when playing online. The most commonly reported was excessive engagement (“addiction”) in which gamers have difficulty stopping, feel guilty for spending too much time playing, and feel that they are neglecting other aspects of their life.

Predictive networks If we assume that edges reflect potentially causal connections between symptoms, network analysis can identify which symptoms have high centrality, suggesting possible targets for clinical intervention (McNally, 2016, p. 97). Additionally, network analysis can identify markers of impending tipping points that mark the shift from a healthy to an unhealthy state

[4] https://www.theguardian.com/books/2016/sep/10/a-boy-made-of-blocks-by-keith-stuart-review-minecraft

(Hofmann & Curtiss, 2018). For example, Leemput et al. (2014) had healthy and depressed subjects rate four moods (content, cheerful, sad, and anxious) on digital devices multiple times per day for 5-6 days, finding that "increased temporal autocorrelation of ratings of negative moods and increased variance in the ratings predicted shifts from healthy to depressed states". This phenomenon is called critical slowing, in which dynamic networks respond more and more sluggishly to perturbations, eventually reaching a tipping point (Leemput et al., 2014; McNally, 2016).

By modeling symptoms of excessive engagement in video gaming as nodes in a dynamic network, we may be able to predict just such a tipping point from a healthy to an unhealthy state, helping us to understand the balance of positive and negative effects and to identify situations in which gaming may be more harmful than helpful. We are just beginning to develop the tools to study phenomena such as excessive engagement, and as the immersive technologies of virtual reality become more prevalent, our relationships with these digital worlds will grow in complexity and importance.

APPENDIX

R Session Information

- R version 3.4.4 (2018-03-15), `x86_64-w64-mingw32`
- Locale: `LC_COLLATE=English_United States.1252`, `LC_CTYPE=English_United States.1252`, `LC_MONETARY=English_United States.1252`, `LC_NUMERIC=C`, `LC_TIME=English_United States.1252`
- Running under: `Windows 10 x64 (build 17134)`
- Matrix products: default
- Base packages: base, datasets, graphics, grDevices, methods, splines, stats, utils
- Other packages: bindrcpp 0.2.2, boot 1.3-20, corpcor 1.6.9, DBI 0.8, dplyr 0.7.4, Epi 2.30, fdrtool 1.2.15, forcats 0.3.0, foreach 1.4.4, Formula 1.2-2, GeneNet 1.2.13, ggplot2 2.2.1, glmnet 2.0-16, gridExtra 2.3, Hmisc 4.1-1, igraph 1.2.1, knitr 1.20, lattice 0.20-35, lavaan 0.6-1, longitudinal 1.1.12, MASS 7.3-49, Matrix 1.2-12, parcor 0.2-6, ppls 1.6-1, psych 1.8.3.3, purrr 0.2.4, qdap 2.2.9, qdapDictionaries 1.0.7, qdapRegex 0.7.2, qdapTools 1.3.3, qgraph 1.4.4, RColorBrewer 1.1-2, readr 1.1.1, reshape2 1.4.3, RSQLite 2.1.0, stargazer 5.2, stringr 1.3.0, survival 2.41-3, tibble 1.4.2, tidyr 0.8.0, tidyverse 1.2.1, xtable 1.8-2
- Loaded via a namespace (and not attached): abind 1.4-5, acepack 1.4.1, arm 1.10-1, assertthat 0.2.0, backports 1.1.2, base64enc 0.1-3, BDgraph 2.46, bindr 0.1.1, bit 1.1-12, bit64 0.9-7, bitops 1.0-6, blob 1.1.1, broom 0.5.0, cellranger 1.1.0, checkmate 1.8.5, chron 2.3-52, cli 1.0.0, cluster 2.0.6, cmprsk 2.2-7, coda 0.19-1, codetools 0.2-15, colorspace 1.3-2, compiler 3.4.4, crayon 1.3.4, d3Network 0.5.2.1, data.table 1.10.4-3, digest 0.6.15, ellipse 0.4.1, etm 0.6-2, evaluate 0.10.1, foreign 0.8-69, gdata 2.18.0, gender 0.5.2, ggm 2.3, glasso 1.8, glue 1.2.0, GPArotation 2014.11-1, grid 3.4.4, gtable 0.2.0, gtools 3.5.0, haven 1.1.1, highr 0.6, hms 0.4.2, htmlTable 1.11.2, htmltools 0.3.6, htmlwidgets 1.0, httr 1.3.1, huge 1.2.7, iterators 1.0.9, jpeg 0.1-8, jsonlite 1.5, labeling 0.3, latticeExtra 0.6-28, lazyeval 0.2.1, lme4 1.1-17, lubridate 1.7.4, magrittr 1.5, matrixcalc 1.0-3, memoise 1.1.0, mi 1.0, minqa 1.2.4, mnormt 1.5-5,

modelr 0.1.1, munsell 0.4.3, network 1.13.0.1, nlme 3.1-131.1, nloptr 1.0.4, NLP 0.1-11, nnet 7.3-12, numDeriv 2016.8-1, openNLP 0.2-6, openNLPdata 1.5.3-4, parallel 3.4.4, pbivnorm 0.6.0, pillar 1.2.1, pkgconfig 2.0.1, plotrix 3.7, plyr 1.8.4, png 0.1-7, R6 2.2.2, Rcpp 0.12.16, RCurl 1.95-4.10, readxl 1.0.0, reports 0.1.4, rJava 0.9-9, rjson 0.2.15, rlang 0.2.0, rmarkdown 1.10, rpart 4.1-13, rprojroot 1.3-2, rstudioapi 0.7, rvest 0.3.2, scales 0.5.0, sem 3.1-9, slam 0.1-42, sna 2.4, statnet.common 4.0.0, stats4 3.4.4, stringi 1.1.7, tm 0.7-3, tools 3.4.4, venneuler 1.1-0, whisker 0.3-2, wordcloud 2.5, xlsx 0.5.7, xlsxjars 0.6.1, XML 3.98-1.11, xml2 1.2.0, yaml 2.2.0, zoo 1.8-1

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